INTRO

Creatine is one of the most extensively studied and researched supplements which is used as an ergogenic aid for athletes and now being used for multiple medical conditions too.

Creatine (alpha - methyl guandino-acetic acid) is naturally produced in the body from reactions involving the amino acids arginine, glycine and methionine in the liver, and in smaller amounts in the kidney and pancreas also.

Externally creatine is consumed in the form of supplement or its naturally present in fish, poultry & meat. Eggs and dairy also contain creatine, but in much lesser amount. Creatine is mostly stored in muscle meat; organ meats such as liver, heart, and kidney have very little.

Creatine monohydrate may be used in a variety of foods. As a food ingredient for functional or nutritional purposes it is intended to be added to products like energy drinks, protein bars, milk shakes, protein powders, meal replacement powders and bars, meat analogues and dry mix drinks. The powder form of creatine monohydrate has been shown to be stable for a minimum of three years at room temperature. Similar stability can be expected when creatine monohydrate is included in dry powders such as protein powders, meal replacement powders and drink mix powders.

Creatine Content in Selected Foods				
	Creatine Content	Amount of each food which needs to be consumed *daily in pounds* for each respective creatine dose		
Food	Grams/pound	3 grams	4 grams	5 grams
Cod	1.4	2.14	2.86	3.57
Beef	2.0	1.5	2	3.33
Herring	3.0-4.5	0.67 - 1	0.88 - 1.33	1.11 - 1.67
Milk	0.05	60 (120 cups)	80 (160 cups)	100 (200 cups)
Pork	2.3	1.30	1.74	2.17
Salmon	2.0	1.5	2	2.5
Shrimp	Trace	---	---	---
Tuna	1.8	1.67	2.22	2.78
Plaice	0.9	3.33	4.44	5.55
Fruits/vegetables	Trace	---	---	---

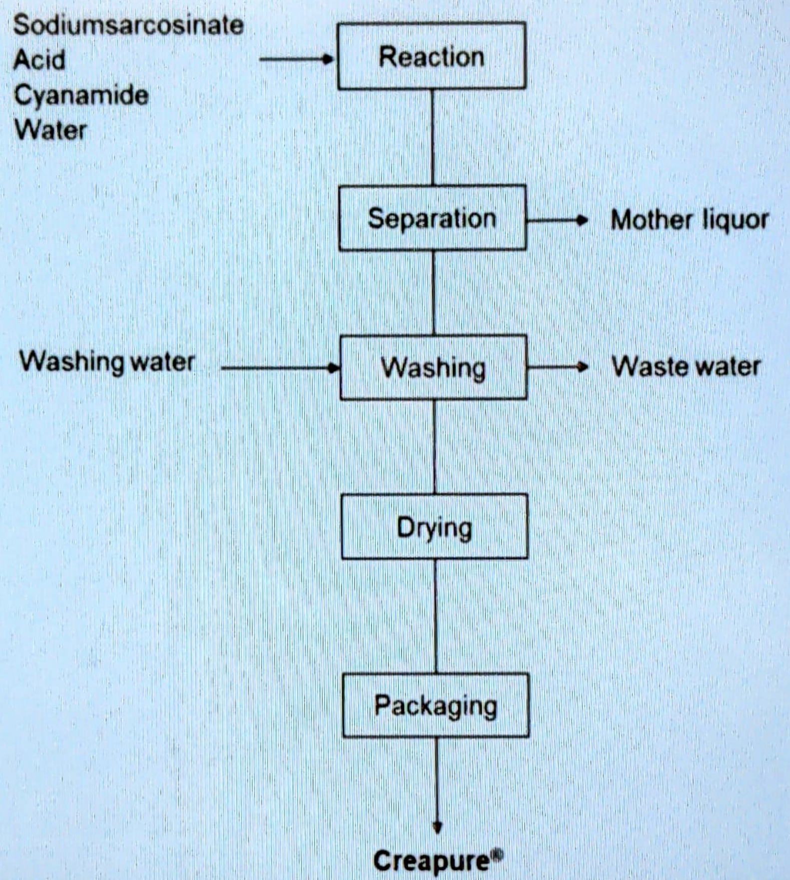
(Image Source)

In 1832, the French scientist & philosopher Michael Eugene Chevreul discovered a new ingredient of beef tissue, which he named creatine. The German scientist von Liebig confirmed that creatine is a regular constituent of flesh. Animals were exclusively used as a source for creatine for about the next century.

If particularly pure material was needed, e.g. for organic preparations and analytical standards, creatine was prepared from meat extract. Twenty-five kilograms of fat-free flesh contains 1 kilogram of this extract which, after

extraction for 3 times with 2 litres of absolute ethanol each and re-crystallization from water, yields 25-30 grams of pure creatine.

Studies in the 1920s showed that consumption of large amounts of creatine did not result in its excretion. This result pointed to the ability of the body to store creatine, which in turn suggested its use as a dietary supplement. In 1912, Harvard University researchers found evidence that ingesting creatine can dramatically boost the creatine content of the muscle. In the late 1920s, after finding that the intramuscular stores of creatine can be increased by ingesting creatine in larger than normal amounts, scientists discovered creatine phosphate, and determined that creatine is a key player in the metabolism of skeletal muscles. In the 1960s, creatine kinase (CK) was shown to phosphorylate ADP using phosphocreatine (PCr) to generate ATP.



(Pic Source)

Creatine supplementation gained mainstream popularity after the 1992 Olympic Games in Barcelona. But creatine supplements designed for strength enhancement were not commercially available until 1993 when a company called Experimental & Applied Sciences (EAS) introduced the compound to the sports nutrition market under the name *Phosphagen*.

Creatine is not a steroid as many people believe. It's also a natural compound, and not made in the lab. Neither is creatine a stimulant. It is found in many pre-workout formulas, along with stimulants like caffeine.

App. 95% of the body's creatine is stored in muscles. Additionally, creatine is also found in the heart, brain and testes. About two thirds of the creatine found in muscles is stored as phosphocreatine (PCr) while the remaining amount of creatine is stored as free creatine.

The total creatine pool (PCr + free creatine) in skeletal muscle averages about 120gms for a 70kg individual. However, the average human has the capacity to store up to 160gms of creatine under certain conditions. Also, the amount of creatine stores increases, as the muscle mass increases.

The body breaks down about 1-2% of the creatine pool per day (about 1-2gms/day) into creatinine in the skeletal muscle. The creatinine is then excreted in urine.

An important point to understand is that, creatine from food is digested slower than creatine taken as a supplement, but total bioavailability is same. So, whether you take creatine supplement, or same amount from corresponding foods, the absorption is same in the body.

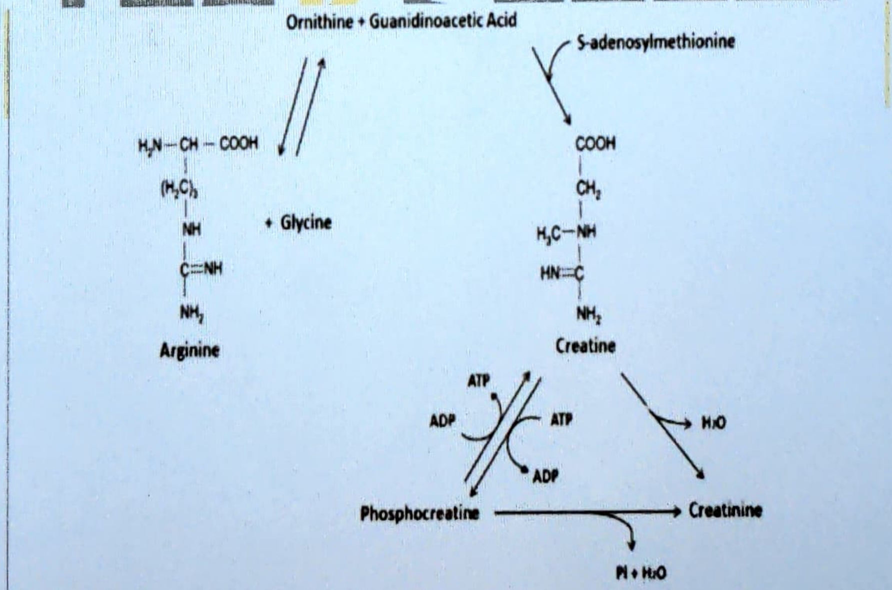
However, the problem with cooking is that creatine gets degraded. Approximately 30% of meat-bound creatine can be lost or degrade into inactive creatinine when cooking to medium-well. That's why supplementation is a better way to take pure creatine, without worries of any degradation, and excess intake of fat or carbs.

The overall bioavailability of creatine is quite good, ranging from 80% up to nearly 100% depending on the dose ingested, since higher acute doses are absorbed less efficiently. In standard dosages (5-10g creatine monohydrate) the bioavailability of creatine in humans is approximately 99%. Absorption does not appear to be hindered by other common

supplements, although too much creatine at one time (greater than 10g) can saturate receptors, leading to excretion.

Starvation increases creatine uptake into cells, but without appreciable conversion into phosphocreatine. Because phosphocreatine is the energetically useful form of creatine in the cell, starvation is not a viable means to increase the efficacy of creatine supplementation. People with initially low levels of creatine are more responsive to supplementation. For e.g. vegetarians.

If you take excess creatine, the body regulates it and only absorbs as much it needs. The two amino acids, glycine and arginine, combine via the enzyme *Arginine:Glycine amidinotransferase* (AGAT) to form ornithine and guanidoacetate. This is the first of two steps in creatine synthesis. AGAT is also the primary regulatory step, and an excess of dietary creatine can suppress activity of AGAT to reduce creatine synthesis.



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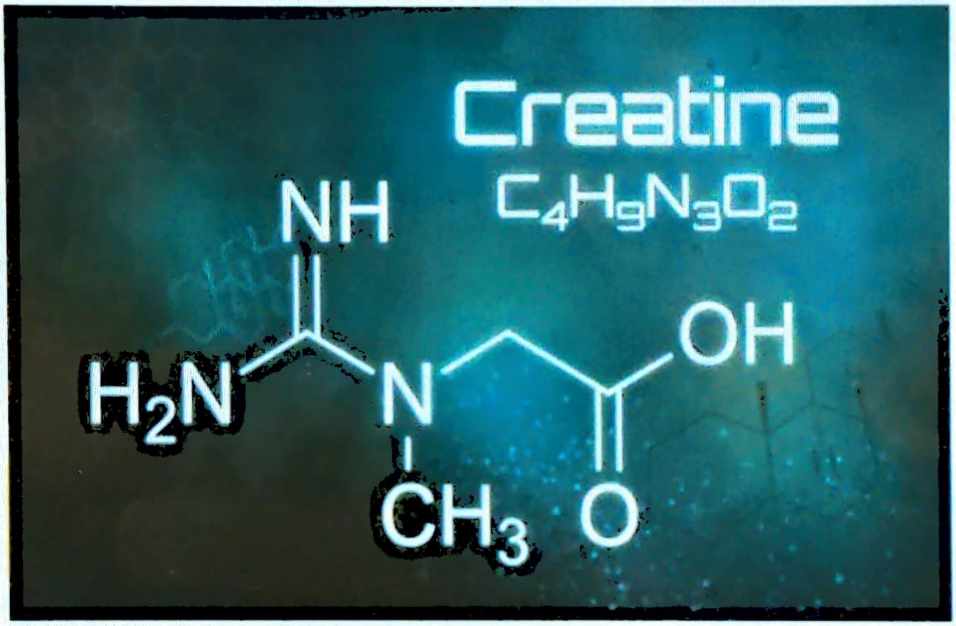
WERSTUPID

THE BASICS OF CREATINE

The 1997 Nobel prize for Chemistry has been awarded to 3 biochemists for the study of the important biological molecule, **adenosine triphosphate (ATP)**.



All living things, plants and animals, require a continual supply of energy in order to function. The energy is used for all the processes which keep the organism alive. Some of these processes occur continually, such as the metabolism of foods, the synthesis of large, biologically important molecules, *e.g.* proteins and DNA, and the transport of molecules and ions throughout the organism. Other processes occur only at certain times, such as muscle contraction and other cellular movements.

Animals obtain their energy by oxidation of foods, plants do so by trapping the sunlight using chlorophyll. However, before the energy can be used, it is

first transformed into a form which the organism can handle easily. This special carrier of energy is the molecule adenosine triphosphate, or ATP.

(Mitochondria are the human body's "furnaces", responsible for producing the energy necessary for all movement and biological processes. These powerhouses, located within cells, convert carbohydrates (glucose, in their most elemental form) to adenosine triphosphate (ATP).)

Chemically, ATP is an adenosine molecule bound to three phosphates. An abundance of potential energy is stored within the bond between the second and third phosphate groups; this energy can be harnessed to fuel chemical reactions.

When ATP breaks down (hydrolysis), it releases large amount of energy, which fuels the cellular reactions. ATP is hydrolysed to ADP.

Even more energy can be extracted by removing a second phosphate group to produce adenosine monophosphate (AMP).

Energy released by high energy phosphate reactions

Reaction	ΔG [kJ/mol]
$ATP + H_2O \rightarrow ADP + P_i$	-30.5
$ADP + H_2O \rightarrow AMP + P_i$	-30.5
$ATP + H_2O \rightarrow AMP + PP_i$	-40.6
$PP_i + H_2O \rightarrow 2\,P_i$	-31.8

Like most chemical reactions, the hydrolysis of ATP to ADP is reversible. The reverse reaction, which regenerates ATP from ADP and P, requires energy. Whenever a cell needs energy, it breaks the phosphate bond to create adenosine diphosphate (ADP) and a free phosphate molecule. A cell stores excess energy by combining ADP and phosphate to make ATP. Thus, the ATP molecule acts as a chemical 'battery', storing energy when it is not needed, but able to release it instantly when the organism requires it.

"The fact that ATP is Nature's 'universal energy store' explains why phosphates are a vital ingredient in the diets of all living things. Modern fertilizers often contain phosphorus compounds that have been extracted from animal bones. These compounds are used by plants to make ATP. We then eat the plants, metabolise their phosphorus, and produce our own ATP. When we die, our phosphorus goes back into the ecosystem to begin the cycle again."

Since energy is released when ATP is broken down, energy is required to rebuild or resynthesize it. The building blocks of ATP synthesis are the by-products of its breakdown; adenosine diphosphate (ADP) and inorganic phosphate (Pi). The energy for ATP resynthesise comes from three different series of chemical reactions that take place within the body. Two of the three depend upon the food eaten, whereas the other depends upon a chemical compound called phosphocreatine (PCr).

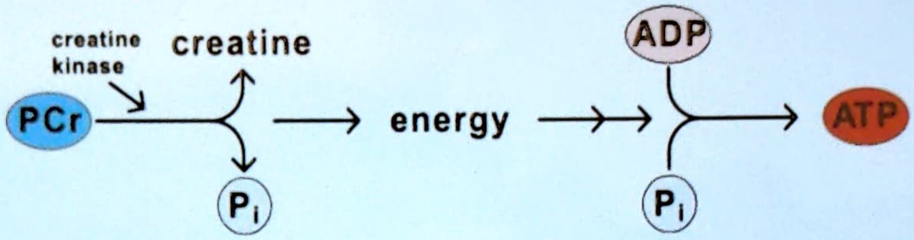
Three processes can synthesize ATP:

- **ATP-CP system (Phosphagen system)** – This system is used for up to 10 seconds. The ATP-CP system neither uses oxygen nor produces lactic acid if oxygen is unavailable. This is the primary system behind very short, powerful movements like a golf swing, a 100m sprint or powerlifting.

- **Anaerobic system** – This system predominates in supplying energy for exercise lasting less than two minutes. It is also known as the glycolytic system. An example of an activity of the intensity and duration that this system works under would be a 400m sprint.

- **Aerobic system** – This is the long-duration energy system. After five minutes of exercise, the O_2 system is dominant. In a 1km run, this system is already providing approximately half the energy; in a marathon run it provides 98% or more.

The energy supplied to rebuild adenosine diphosphate (ADP) into adenosine triphosphate (ATP) during and following intense exercise is largely dependent on the amount of phosphocreatine (PCr), which is stored in the muscles. When it is broken down, a considerable amount of energy is released. The energy released is coupled to the energy requirement necessary for the resynthesise of ATP.



The total muscular stores of both ATP and CP are small. Thus, the amount of energy obtainable through this system is limited. The phosphagen stored in the working muscles is typically exhausted in seconds of vigorous activity.

From a biological standpoint, the ATP-PC system plays the most significant role in the "*fight or flight*" phenomenon (driven by the sympathetic nervous system state). This ATP-PC energy system provides short, explosive bursts of power that are most activated by a survival instinct (running away from the tiger or standing to fight the tiger). In a life and death situation, you want to be able to activate the most potent energy system you have.

The ATP-PC system is responsible for providing energy to the highest threshold muscle fibres that are capable of producing the greatest levels of force. It makes sense that bigger stronger muscles generate more power due to their storage capacity for phosphocreatine.

This high energy output places high levels of acute stress on the nervous system and quickly depletes local Adenosine Triphosphate (ATP) stores in the muscles, therefore long rest periods are required between repeated efforts.

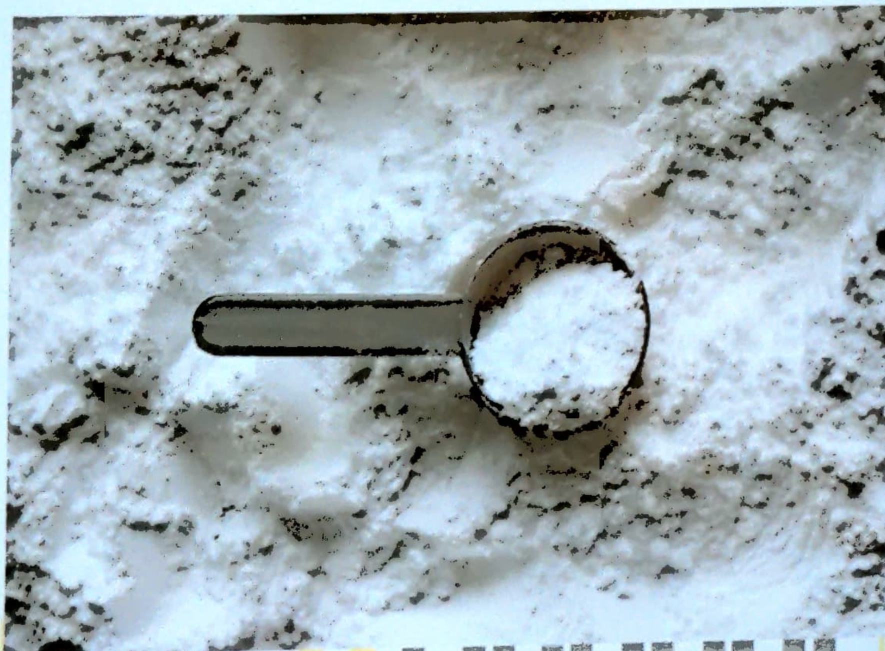
Training the ATP-PC energy system can be achieved by using short (3-10sec) high power demand physical activities followed by 1-3+ minutes of rest. The very high power demands require an extended period of rest to allow for the system to recharge.

As PCr stores become depleted during intense exercise, energy availability diminishes due to the inability to resynthesize ATP at the rate required to sustained high-intensity exercise. Consequently, the ability to maintain maximal-effort exercise declines.

The availability of PCr in the muscle may significantly influence the amount of energy generated during brief periods of high-intensity exercise. For sports and exercises that require explosive and powerful muscle contraction, there is a lot of interest in maximising phosphocreatine in the muscles to boost performance. If you have more phosphocreatine in a muscle, you are able to endure a longer period of intense muscle contraction before the muscle is fatigued and loses power.

Furthermore, increasing muscle creatine content, via creatine supplementation, may increase the availability of PCr allowing for an accelerated rate of resynthesise of ATP during and following high-intensity, short-duration exercise. Creatine supplementation during training leads to greater training adaptations due to an enhanced quality and volume of work performed.

CREATINE BENEFITS



Increasing cellular survival (preventing ATP depletion allows cells to survive longer) against hypoxia, oxidative damage, and some toxins that damage neurons and skeletal muscle cells is a mechanism of creatine supplementation mediated via creatine-kinase. This is because, Creatine and phosphocreatine surplus in a cell serves as an energy reservoir that can protect cells during periods of acute stress, and may enhance cell survival.

Creatine kinase levels is genetically decided in the bodies, and differs from person to person. It also varies in different sex and race. Males show higher creatine kinase levels, and black people appear to have higher creatine kinase levels, as compared to white and Hispanics, and Hispanics have higher than white.

On the other hand, exercise will also increase the activity of creatine kinase. Therefore, sedentary people have a lower creatine kinase activity.

A meta-analysis study, found that, oral creatine supplementation combined with resistance training increases maximal weight lifted in young men.

Another meta-analysis study, found that, the effect was greater for changes in lean body mass following short-term creatine intake, repetitive-bout laboratory-based exercise tasks (e.g., isometric, isokinetic, and isotonic resistance exercise), and upper-body exercise.

According to the two meta-analyses on the topic, creatine significantly increases power when supplemented in both sexes over a period of time up to 8 weeks, during which improvement over placebo is maintained, rather than being enhanced further. The rate at which power is derived from a resistance training regimen appears to be up to 78.5% greater with creatine relative to placebo, and in active trained men who are naive to creatine, this can be quantified at about 7kg for the bench press and 10kg for the squat over 8 weeks.

Creatine supplementation can also increase muscle fibre size independent of protein synthesis, as increasing water content in muscle cells increases their diameter. In a study, 12 young men were supplemented with either a placebo (PL) or Creatine monohydrate (loading phase, 20g/day x 3 days; maintenance phase, 5g/day x 7 days) for 10 days. Creatine supplementation significantly increased fat-free mass, total body water, and body weight of the participants.

Research has shown that, creatine supplementation enhances fat-free mass, physical performance, and muscle morphology in response to heavy resistance training, presumably mediated via higher quality training sessions.

Acc. to a meta-analysis study, creatine supplementation combined with resistance training increased lean body mass (LBM) by 1.1 kg in adults, regardless of age (i.e., young, middle-aged, and older adults). Males supplementing with creatine experienced a greater increase in LBM than females during a resistance training program. Creatine supplementation alone (with no exercise training intervention) was ineffective for LBM gains.

"*Creatine may play a role in topical anti-aging skin products with a concentration of about 0.02% of the cream, and theoretically can enhance the effects of other agents by providing more energy for a skin cell to use. Creatine may inherently have a pro-collagen effect, reduce wrinkle formation, and improve skin integrity*"

"*Creatine supplementation appears to have some minor protective effects on humans undergoing chemotherapy, where it has reduced fat gain from chemotherapy (leukaemia) and has improved some biomarkers of cell viability. The anti-cancer effects of creatine suggest it may act as an anti-tumour agent. It may also be negatively correlated with tumour production, with higher concentrations of creatine being associated with less tumour progression*".

The benefits of creatine monohydrate supplementation go well beyond increasing muscle Creatine and PCr levels and thereby enhancing high-intensity exercise and training adaptations. Research has clearly shown several health and/or potential therapeutic benefits as we age and in clinical populations that may benefit by enhancing Creatine and PCr levels. Based on the available evidence, the following can be reasonably concluded based:

1. *Creatine supplementation can increase cellular energy availability and support general health, fitness, and well-being throughout the lifespan.*
2. *Creatine supplementation, particularly with resistance training, can promote gains in strength and help maintain or increase muscle mass in older individuals. Additionally, creatine supplementation during energy-restriction-induced weight loss may be an effective way to preserve muscle while dieting and thereby help manage adult-onset obesity.*

3. Creatine supplementation may support cognitive function, particularly as one ages.
4. Creatine supplementation may support healthy glucose management.
5. Phosphocreatine administration and possibly creatine supplementation may support heart metabolism and health, particularly during ischemic challenges.
6. Long-term, high-dose creatine supplementation in individuals with creatine synthesis deficiencies can increase brain creatine and PCr levels and may reduce the severity of deficits associated with these disorders.
7. Although creatine supplementation has been shown to have neuroprotective properties and improve strength and endurance, the efficacy of long-term, high-dose creatine supplementation in individuals with neurodegenerative diseases is equivocal, while promising, in patients with muscular dystrophy.
8. Creatine supplementation may increase brain creatine content, enhance energy availability during ischemic events, and provide neuroprotection from TBI and/or SCI.
9. Creatine supplementation prior to and following injury may reduce immobilization-related atrophy and/or enhance rehabilitative outcomes in a number of populations.
10. Creatine supplementation during pregnancy may help support the mother and child's nutritional needs and health; however, due to the limited studies in pregnant humans, caution should be exercised when recommending use during human pregnancy.
11. Creatine supplementation may have anti-inflammatory and immunomodulating effects.
12. Creatine is an important energy source for immune cells, can help support a healthy immune system, and may have some anti-cancer properties.
13. Creatine and/or GAA may improve functional capacity in patients with chronic fatigue-related syndromes such as post-viral fatigue syndrome (PFS) and myalgic encephalomyelitis (ME).

CREATINE DEFICIENCY

People with creatine deficiency showcases neural defects and problems. Patients with creatine deficiency syndromes present with mental retardation expressive speech and language delay, epilepsy, autistic behaviour.

This is called cerebral creatine deficiency syndromes (CCDS), inborn errors of creatine metabolism, include the two creatine biosynthesis disorders, guanidinoacetate methyltransferase (GAMT) deficiency and L-arginine:glycine amidinotransferase (AGAT) deficiency, and the creatine transporter (CRTR) deficiency. Intellectual disability and seizures are common to all three CCDS (https://bit.ly/3knhypU).

Guanidinoacetate methyltransferase (GAMT) deficiency and arginine-glycine amidinotransferase (AGAT) deficiency are treatable by oral

creatine supplementation, but patients with creatine transporter deficiency do not respond to this type of treatment.

As we saw that, meat products are the main source of creatine, therefore, vegetarians, specially vegans have reportedly shown to have lower levels of muscle creatine. Creatine supplementation, that's why can be a very useful way to enhance creatine stores in vegetarians/vegans.

Because creatine functioning influences brain functioning, in vegetarians rather than in those who consume meat, creatine supplementation had resulted in better memory & intelligence.

Creatine has been demonstrated to increase cognition (memory, learning, and performance) in people with no dietary creatine intake, like vegetarians and vegans. These benefits also appears to extend to the sleep deprived and elderly people without any salient cognitive decline.

Creatine has limited potential in increasing cognition in otherwise healthy young omnivores, but it does possess a general pro-cognitive effect.

A meta-analysis of RCTs, found that, creatine supplementation enhanced measures of memory performance in healthy individuals, especially in older adults (66–76 years).

A study found that, creatine supplementation can increase brain creatine content, which over time may help explain some of the promising effects on measures of brain health and function. Specifically, creatine supplementation has been shown to improve measures of cognition and memory (primarily in aging adults) and decreases symptoms of sleep deprivation in human and animal populations.

In a study, researchers examined the effect of creatine supplementation and sleep deprivation, with intermittent moderate-intensity exercise, on

cognitive and psychomotor performance, mood state, effort and salivary concentrations of cortisol and melatonin.

Subjects were divided into a creatine supplementation group and a placebo group. They took 5g of creatine monohydrate or a placebo, dependent on their group, four times a day for 7 days immediately prior to the experiment. They undertook tests examining central executive functioning, short-term memory, choice reaction time, balance, mood state and effort at baseline and following 18-, 24- and 36-h sleep deprivation, with moderate intermittent exercise.

Researchers found that 5g of creatine four times daily for a week (loading) before sleep deprivation for 12-36 hours was able to preserve cognition during complex tasks of executive function at 36 hours only, without significant influence on immediate recall or mood.

Another study, examined the effect of creatine supplementation and sleep deprivation, with mild exercise, on cognitive and psychomotor performance, mood state, and plasma concentrations of catecholamines and cortisol. Researchers found that, following 24-h sleep deprivation, creatine supplementation had a positive effect on mood state and tasks that place a heavy stress on the prefrontal cortex.

WERSTUPID

WHICH FORM OF CREATINE IS BEST?

Creatine is probably the most famous ergogenic supplements used in sports and has tons of research supporting its effectiveness as well as safety. But whenever a supplement gets known, a lot of companies jump in and start offering fancier forms of the same supplement with more attractive packaging, claiming extra benefits over other forms.

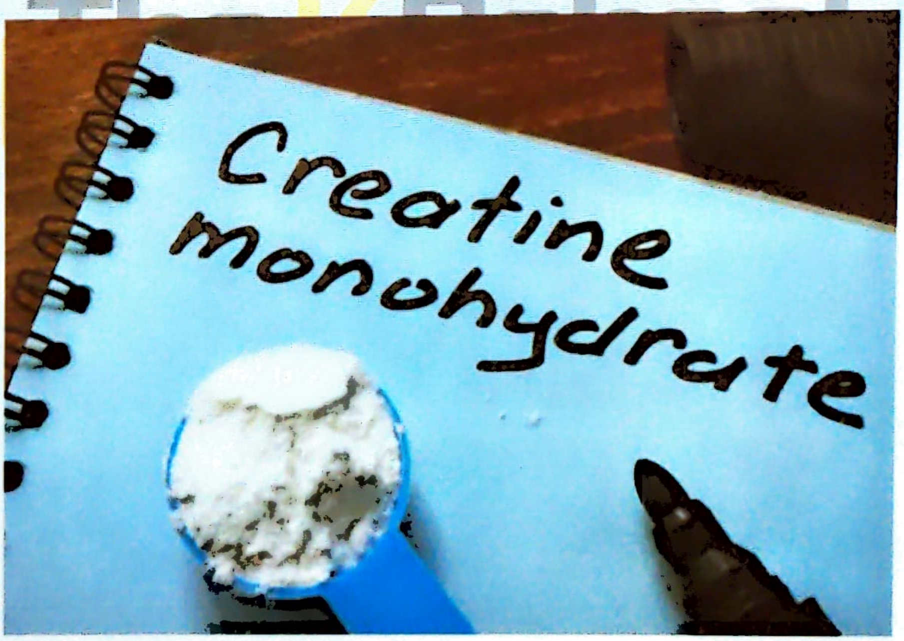
The basic form of creatine comes in two forms, one of which involves the removal of the monohydrate (which results in creatine anhydrous). Due to the exclusion of the monohydrate it is 100% creatine by weight despite creatine monohydrate being 88% creatine by weight, as the monohydrate is 12%.

Creatine today comes in many forms. It started from the basic creatine monohydrate and is still the most exclusively used form. Then there are other forms like creatine ethyl ester, creatine magnesium chelate, creatine

citrate, buffered creatine (Kre-Alkalyn), creatine hydrochloride, creatine pyruvate, creatine nitrate etc.

These newer forms have been purported to have better physical and chemical properties, bioavailability, efficacy, and/or safety profiles than CM. However, there is little to no evidence that any of the newer forms of creatine are more effective and/or safer than CM whether ingested alone and/or in combination with other nutrients. In addition, whereas the safety, efficacy, and regulatory status of CM is clearly defined in almost all global markets; the safety, efficacy, and regulatory status of other forms of creatine present in today's marketplace as a dietary or food supplement is less clear.

Creatine monohydrate is the basic form used and is the gold standard in creatine use. It is not degraded during normal digestion and that nearly 99% of orally ingested creatine monohydrate is either taken up by muscle or excreted in urine.



Creatine in Micronized form is creatine that has been processed to reduce the particle size of the powder. Micronization may increase the solubility in water, but it doesn't make it any more effective, neither is it better absorbed than the basic creatine monohydrate form.

The other forms and brands, provide the same or lesser effect than the good old creatine monohydrate. None have proven to have an edge over the basic creatine monohydrate form. The only difference is that the newer and fancier forms of creatine simply cost more, because of overhyped marketing. Creatine monohydrate, on the other hand is one of the cheapest forms available. Being cheap doesn't mean less effective and vice versa.

For e.g. **Creatine HCL** is creatine molecule bound to hydrochloric acid. Companies claim it to have a higher level of absorption, but there isn't any study proving this statement. Creatine HCL breaks into free creatine and HCL in the stomach, which is equivalent to creatine monohydrate only.

There are people trying to sell creatine HCL with some patented technology, claiming it to be much superior, but there isn't even a single piece of evidence so far on such claims.

There was one study which tried to prove creatine HCL to be superior to creatine monohydrate. It found that strength was increased in both creatine monohydrate and HCL subjects, with no statistically significant difference between the two. The study actually wrongly concluded that subjects who took HCL had a higher decrease in fat mass. As, the difference is hardly anything. Also, the subject count is way too small to really conclude much out of the study.

Some companies claim the **liquid creatine** to be better than powdered creatine. But this fact was not proven false, but liquid creatine has shown to be less effective than creatine monohydrate.

In fact, certain studies, have shown that creatine being in a liquid for a long time, starts to break down and gets less effective. This problem doesn't happen immediately, so don't worry when you are adding creatine to your water for regular consumption. This happens when you keep creatine in liquid for days together, when the breakdown starts to happen.

Creatine monohydrate powder is very stable showing no signs of degradation into creatinine over years, even at elevated storage temperatures. The degradation of creatine can be reduced or halted by lowering the pH under 2.5 or increasing the pH above 12.1. This is the reason that less than 1% of creatine monohydrate is degraded to creatinine during the digestive process and creatine is taken up by tissue or excreted in urine after ingestion. Moreover, since creatine is an ampholytic amino acid, it is not very soluble in water. Moreover, creatine is not very soluble in water (e.g., creatine monohydrate dissolves at 14 g/L at 20deg C with a ~~neutral pH of 7). Mixing~~ creatine in higher temperature solution increase solubility.

The lack of solubility and stability of creatine in solution is the reason that creatine is primarily marketed in powder form and efforts to develop stable beverages containing physiologically effective doses of creatine (e.g., 3–5g per serving) have been unsuccessful.

When it comes to **Buffered Creatine**, study showed that, Buffered creatine (Kre-Alkylyn is the brand name), **didn't promote greater changes in muscle** creatine content, body composition, strength, or anaerobic capacity, than creatine monohydrate. There was no evidence that supplementing the diet with a buffered form of creatine resulted in fewer side effects than Creatine monohydrate.

Another form of creatine, **Creatine Ethyl Ester**, when compared to creatine monohydrate, creatine ethyl ester was not as effective at increasing serum and muscle creatine levels or in improving body composition, muscle mass, strength, and power. Creatine ethyl ester is 82.4% creatine by weight, and thus would provide 8.2g of active creatine for a dosage of 10g.

On the other hand, Creatine Ethyl Ester, when compared to monohydrate, also results in higher levels of creatinine in the urine. Since creatinine is a

widely used marker for renal function, the use of Creatine ethyl ester, may lead to a false assumption of renal failure.

Creatine magnesium Chelate is next, which has shown to exert similar effects as creatine monohydrate in boosting strength & power. Magnesium chelated creatine may be useful for increasing muscle strength output with a similar potency to creatine monohydrate, but without the water weight gain, as there are noted differences, but they are statistically insignificant.

Creatine Nitrate, is a form of creatine in which a nitrate (NO3) is bound to creatine molecule. It has again shown similar benefits to creatine monohydrate when it comes to safety and exercise performance.

The other form is Creatine Citrate, where creatine is bound to citrate or citric acid molecule. It has no difference in terms of absorption as compared to creatine monohydrate. It is, however, more soluble in water as compared to monohydrate. But this does not make any special difference in terms of effectiveness.

The same is the case with Creatine Malate, but again there is no difference in terms of effectiveness when it comes to comparison with monohydrate.

Creatine Pyruvate, when compared to monohydrate form, has shown to have similar bioavailability or absorption.

Creatine α-ketoglutarate is the creatine molecule bound to an alpha-ketoglutaric acid, and is believed to be an enhanced form of creatine. However, there is no evidence of this fact.

Sodium Creatine Phosphate appears to be about half creatine by weight, and it is not certain if this variant offers any advantages over conventional forms.

Polyethylene Glycosylated Creatine seems to be as effective as creatine monohydrate at a lower dose (1.25-2.5g relative to 5g monohydrate), but did not alter Body mass, power output, or endurance.

Creatine gluconate is a form of creatine supplementation in which the creatine molecule is bound to a glucose molecule. It currently does not have any studies conducted on it.

The K School

DOES CREATINE CAUSE WATER RETENTION, DEHYDRATION & CRAMPS?

A common doubt pertaining to creatine use is that we need to increase the water intake post creatine consumption. If not, then it will cause cramping, dehydration etc. especially when working out in a hot environment. The concern about dehydration when taking creatine supplements is largely due to your muscle tissue retaining water. This is the reason you may experience weight gain after just a week of supplementing creatine.

When creatine is absorbed it pulls water in with it, causing cells to swell. This "cell volumization" is known to promote a cellular anabolic state associated with less protein breakdown and increased DNA synthesis.

1. A study, evaluated 1) the changes in total body weight and body water in response to creatine monohydrate supplementation, and 2)

if the hypothesized increases did occur, to determine whether this was sufficient to alter thermal regulation as measured by rectal temperature during a 60min ride at 37deg C.

The results indicated that creatine supplementation elevates body mass. These increases may partially reflect changes in body water stores and may be enough to improve thermal regulation during exercise in the heat, as evidenced by an attenuated rise in rectal temperature over a 60min period of exercise post-supplementation. Further, amid anecdotal reports that creatine causes dehydration, muscle cramping, and heat exhaustion, **the subjects in this study reported no overt side effects of creatine supplementation.**

2. A study, examined the influence of creatine (Cr) supplementation on acute cardiovascular, renal, temperature, and fluid-regulatory hormonal responses to exercise for 35 min in the heat. Twenty men were assigned to consume 0.3g/kg Cr monohydrate or placebo for 7 days. Before and after supplementation, both groups cycled for 30 min at 60-70% VO2 immediately followed by three 10 sec sprints in an environmental chamber at 37deg C and 80% relative humidity.

Body mass was significantly increased in Cr subjects. Heart rate, blood pressure, and sweat rate responses to exercise were not significantly different between groups. Sodium, potassium, and creatinine excretion rates obtained from 24h and exercise urine collection periods were not significantly altered in either group. Serum creatinine was elevated in the Cr group but within normal ranges.

Peak power was greater in the Cr group during all three 10 sec sprints after supplementation and unchanged in the placebo group. There were **no reports of adverse symptoms, including muscle cramping during supplementation or exercise. Researchers thus**

concluded that, Cr supplementation augments repeated sprint cycle performance in the heat without altering thermoregulatory responses.

3. A study, examined the effects of creatine monohydrate supplementation on total body weight (TBW), percent body fat, body water content, and caloric intake, in seventeen men. Subjects were assigned to a creatine or placebo group. Supplementation was given for 4 weeks (30g/day for the initial 2 weeks and 15g/day for the final 2 weeks). Subjects reported 2 days a week of strength training of the lower extremity.

Significant increases before and after the study were found in TBW and body water content for the creatine group. No significant changes were found in percent body fat or daily caloric intake in the creatine group. No significant changes were noted for the placebo group. These findings support the fact that creatine supplementation

increases TBW. Mean percent body fat and caloric intake was not affected by creatine supplementation. Therefore, weight gain in lieu of creatine supplementation may in part be due to water retention.

4. A study, examined the effects of oral creatine (Cr) monohydrate supplementation on muscle Cr concentration, body mass, and total body water (TBW), extracellular water (ECW), and intracellular water (ICW) volumes. After an overnight fast, urinary Cr and creatinine concentrations, muscle Cr concentration, body mass, TBW, ECW, and ICW were measured, and subjects were randomly assigned to either a Cr or a placebo (P) group. The Cr group ingested 25g/d of Cr for 7 days (loading phase) and 5g/d for the remaining 21 days (maintenance phase), whereas the P group ingested a sucrose P using the same protocol. Sixteen men and 16 women involved in resistance training participated in this study.

   The results indicated that the supplementation protocol was effective in increasing muscle Cr concentrations. Increased muscle Cr content was associated with an increased body mass and TBW volume. Thus, supplementation does result in water retention.

   It was initially hypothesized that the water would be preferentially retained intracellularly, altering fluid distribution. However, this was not observed. Therefore, the **theory of a Cr-related fluid shift is not supported because fluid distribution remained normal.**

   An alteration in fluid distribution during supplementation had been suggested as a cause of muscle cramping and other heat-related problems anecdotally associated with Cr supplementation. Because the subjects failed to experience any side effects beyond weight gain, it cannot be determined whether athletes supplementing their habitual diet with oral Cr monohydrate will be more predisposed to muscle cramping and heat illness than athletes who are not ingesting

Cr. However, the results do not support the fluid-shift theory behind Cr supplementation and heat illness.

"Creatine does indeed cause cellular volumization and that's an important determinant of protein breakdown and protein synthesis in skeletal muscle (and other cell types, too). Working out turns on protein synthesis while simultaneously breaking down protein, but creatine shifts the balance towards protein synthesis.

Yes, creatine supplies an extra phosphate group to help regenerate ATP during high-intensity contractions, but cell volumization is an even more important cause of creatine's muscle-building effect.

Long-term use is a slightly different scenario because that's when creatine increases fat-free mass without a concomitant increase in total body water. Muscle fibre diameter goes up, along with strength, so long-term effects appear to be caused largely by increased muscle mass".

5. A study, examined the effects of creatine supplementation on the incidence of injury observed during 3-years of college football training and competition. Athletes participating in the 1998-2000 football seasons were elected to take creatine or non-creatine containing supplements following workouts/practices.

   Subjects who decided to take creatine were administered 15.75g of creatine for 5 days followed by ingesting an average of 5g/day thereafter administered in 5-10g doses. Subjects practiced or played in environmental conditions ranging from 8-40deg C and 19-98% relative humidity.

Researchers found that, the incidence of cramping, heat/dehydration, muscle tightness, muscle pulls/strains, non-contact joint injuries, contact injuries, illness, number of missed practices due to injury, players lost for the season, and total injuries/missed practice, were generally lower or proportional to the creatine use rate among players. **Creatine supplementation does not appear to increase the incidence of injury or cramping** in college football players.

6. A [study](), hypothesized that creatine supplementation would interfere with normal body fluid shifts that occur during exercise in a hot environment. This study examined the effects of acute creatine loading (20g/d for 5 days) on the thermoregulatory response of the body during a bout of exercise at 39deg C.

Subjects (15 men and 1 woman) performed a cycle test of maximum oxygen consumption to determine the proper work rate for the heat-stress test (40min at 39deg C) and were assigned to a creatine

group or a placebo group. Each group performed the heat-stress test on two separate occasions: before supplementation and after supplementation (20g/d of creatine with Gatorade or placebo plus Gatorade).

Researchers found that, short-term creatine supplementation (20g/d for 5 days) did not have a negative effect on thermoregulatory responses during exercise at 39deg C.

7. A study, assessed whether 1 week of creating monohydrate supplementation would compromise hydration status, alter thermoregulation, or increase the incidence of symptoms of heat illness in dehydrated men performing prolonged exercise in the heat.

   For the study, 12 active males, consumed 21.6gms/day of creatine monohydrate or a placebo for 7 days. On day 7 of each treatment, subjects lost 2% body mass by exercising in 33.5deg C and then completed an 80-minute exercise heat-tolerance test. The test consisted of four 20-minute sequences of 4 minutes of rest, alternating a 3-minute walk and 1-minute high-intensity run 3 times, and walking for 4 minutes.

   The study showed that, short-term Creatine monohydrate supplementation does not adversely affect thermoregulatory, cardiorespiratory, metabolic, or perceptual responses in people exercising under thermal stress; and short-term creatine monohydrate supplementation was not associated with increased incidence of negative side effects (i.e., cramping or heat illnesses and injuries). Thus, Short-term creatine supplementation did not increase the incidence of symptoms or compromise hydration status or thermoregulation in dehydrated, trained men exercising in the heat.

8. A study, determined the effects creatine (Cr) loading may have on thermoregulatory responses during intermittent sprint exercise in a hot/humid environment. Ten physically active, heat-acclimatized men performed 2 sessions of an exercise test consisting of a 30-minute low-intensity warm-up followed by 6 x 10 second maximal sprints on a cycle in the heat (35deg C).

Subjects then participated in 2 different weeks of supplementation. The first week, subjects ingested 5g of a placebo (maltodextrin) in 4 flavoured drinks (20g total) per day for 6 days and were retested on day 7. The second week was similar to the first except a similar dose (4 x 5g/day) of creatine monohydrate (Cr) replaced maltodextrin in the flavoured drinks.

Six days of Cr supplementation produced a significant increase in body weight, whereas the P did not. Compared to pre-exercise measures, the exercise test in the heat produced a significant increase in core temperature, a loss of body water determined by body weight

change during exercise, and a relative change in plasma volume; however, these were not significantly different between P and Cr. Sprint performance was enhanced by Cr loading. Peak power and mean power were significantly higher during the intermittent sprint exercise test following 6 days of Cr supplementation.

It appears that ingestion of Cr for 6 days does not produce any different thermoregulatory responses to intermittent sprint exercise and may augment sprint exercise performance in the heat.

9. A study, suggested that, despite the abundance of research suggesting the effectiveness and safety of creatine, a fallacy appears to exist among the general public, driven by media claims and anecdotal reports, that creatine supplementation can result in muscle cramps and dehydration.

Acc. to the researchers "*Recent reports now suggest that creatine may enhance performance in hot and/or humid conditions by maintaining haematocrit, aiding thermoregulation and reducing exercising heart rate and sweat rate. Creatine may also positively influence plasma volume during the onset of dehydration. Considering these new published findings, little evidence exists that creatine supplementation in the heat presents additional risk.*"

10. A study, researched the effect of creatine supplementation on exercise heat tolerance and hydration status. Researchers found that, the first time creatine gained attention was in 1997 when three NCAA wrestlers died, for which creatine was blamed. However, autopsy results determined that exertional heat stroke, not creatine, was responsible for these deaths. Such speculations also came later, blaming creatine, but all of them have been debunked.

Theoretically, creatine uptake by the muscles results in an increase in fluid volume within skeletal muscle cells. Acc. to the researchers, theoretically, creatine uptake by the muscles results in an increase in fluid volume within skeletal muscle cells. Whether this increase helps, hinders, or does not influence thermoregulation has not been determined.

Researchers, after analysing over fifteen studies, concluded that, "***No substantial evidence currently exists showing that creatine supplementation hinders the body's ability to dissipate heat or body fluid balance when appropriate doses are consumed. Controlled experimental trials of athletes exercising in the heat over a short period of time resulted in no adverse effects from creatine supplementation.***"

11. "*Although many recent studies have addressed the safety concerns of creatine supplementation on hydration status in hot and humid environments, anecdotal reports still exist linking creatine usage to*

heat-related problems. These concerns are based on the premise that creatine is an osmotically active substance resulting in an alteration in fluid balance by increasing intracellular fluid volume and preventing fluid from entering the extracellular environment to aid in thermoregulation.

However, a number studies have demonstrated that when recommended amounts of creatine are consumed, creatine does not appear to increase the risk of heat-related problems during exercise and may actually have a positive influence on core temperature and heart rate responses."

12. Acc. to a study, creatine has the ability to remove plasma water from the blood-stream into skeletal muscle in a process called muscle myofibrillar hydration. Although this benefits the skeletal muscles, less water is available to other tissues since most cell physiological and chemical reactions in the body need water.

For the study, adult males between the age of 18-35yrs were advised to use 0.3grams of creatine per kilogram for several weeks. Researchers found that, 34.5% of people who used creatine experienced weight gain, but did not manifest signs of dehydration at the indicated dose.

Acc. to the researchers, although at lower doses of 3grams there is no scientific evidence that risk of dehydration occurs, the recommendation is to **maintain a high fluid intake (200-250ml of water per 2.5grams of creatine) since this water needs to be stored and if the availability is low, it decreases absorption and retention within the cell.** There is no evidence that taking creatine in normal doses increases heat stress or adversely affects the performance of the athlete in warm environments.

13. A study, evaluated changes in total body water (TBW) in soccer athletes after 7 days of creatine supplementation. 13 (under-20) soccer players were divided randomly in 2 supplementation groups: Placebo and creatine supplementation. Before and after the supplementation period (0.3g/kg/d during 7 days), TBW was determined.

    7 days of creatine supplementation lead to a large increase in TBW and a small but significant increase in total body weight in creatine group compared to placebo group.

Only potential side-effects are nausea, stomach cramps, and diarrhoea from too large a dose. Creatine causes some water retention, but if you exercise, with time the proportion of added muscle to added water will increase .

Creatine is known to cause mild water retention and decreased urinary volume due to its osmotic effect. This may result in temporary weight gain, particularly during the loading phase. However, no adverse effects have been reported because of this.

Creatine is an osmotically active substance. Thus, an increase in the body's creatine content could theoretically result in increased water retention. Creatine is taken up into muscle from circulation by a sodium-dependent

creatine transporter. Since the transport involves sodium, water will also be taken up into muscle to help maintain intracellular osmolality. However, it is not likely that intracellular sodium concentration is dramatically affected by creatine supplementation.

So, creatine does draw water from in your blood stream and stores additional water within your muscles, which is why when you begin taking creatine, your muscles may feel fuller. This means that it can also draw water away from other parts of the body. However, this does not make you dehydrated, as the studies have shown. Also, there is no relation to taking creatine and dehydration, cramping and other adverse effects when working out in heat.

While there is some evidence to suggest that creatine supplementation increases water retention, primarily attributed to increases in intracellular volume, over the short term, there are several other studies suggesting it does not alter total body water (intra or extracellular) relative to muscle mass over longer periods of time. As a result, creatine supplementation may not lead to water retention.

People saying that, they have gained weight in stomach after taking creatine are just fat. The water retention happens in the muscles, not in the stomach.

DOES CREATINE DAMAGE YOUR KIDNEYS?

One of the evergreen myths about creatine, is that creatine supplementation may damage the kidneys.

The reason this myth originated was:

- Kidneys are the major detoxifying organs of the body, and once creatine is absorbed from the intestines, it will pass through the kidneys.
- Creatine is known to be processed by the kidneys. When the creatine breaks down, its by-product is creatinine, which passes out of the urine.

Creatinine is a chemical waste product produced by muscle metabolism. When your kidneys are functioning normally, they filter creatinine and

other waste products out of your blood. These waste products are removed from your body through urination.

A test called as the Creatine Clearance Test is done to assess kidney function. This test allows your healthcare provider to look at samples of your urine and blood to see how much of the waste product — creatinine — is filtered out by your kidneys. Done in two parts, the creatinine clearance test involves collecting your urine over a 24-hour period of time and then having your blood drawn. High levels of creatinine may indicate that your kidney is damaged and not working properly.

Creatinine is measured in milligrams per decilitre of blood (mg/dL). People who are more muscular tend to have higher creatinine levels. Results may also vary depending on age and gender. Creatinine is actually a waste product of creatine.

Since creatine supplementation may increase creatinine levels, it may act as a false indicator of renal dysfunction.

Both blood and urinary creatinine may be increased by ingestion of creatine supplementation and creatine containing foods, such as meat. Creatine is normally not present in urine, but can reach very high levels (>10gm/ day) during creatine supplementation. There appears to be an unsubstantiated perspective that if the kidneys are "forced" to excrete higher than normal levels of creatine or creatinine, some sort of kidney "overload" will take place, causing kidney damage and/or renal dysfunction. In reality, transient increases in blood or urinary creatine or creatinine due to creatine supplementation are unlikely to reflect a decrease in kidney function. Additionally, one must exercise caution when using blood creatinine and estimated creatinine clearance/glomerular filtration rate in individuals who consume high meat intake or supplement with creatine.

Let's see the studies. All the studies done so far have proven, that people with healthy kidney function, will no effect from creatine supplementation.

The scare of creatine's adverse effect on renal functioning started from an old study, which reported that creatine supplementation was detrimental to renal glomerular filtration rate (GFR) in a 25-year-old man who had previously presented with kidney disease (glomerulosclerosis and corticosteroid-responsive nephritic syndrome).

Since that time, other individual case studies have been published posing that creatine supplementation caused deleterious effects on renal function.

1. A study, assessed a single 18-year-old patient, who had normal kidney function, but developed symptoms of nausea, vomiting, and stomach ache when he took creatine just for 5 days at the rate of 20grams for first five days and then 1gram/day for 6 weeks. On diagnosis, it was seen that the patient had acute renal failure. Twenty-five days after stopping the creatine supplementation, the patient recovered fully.

   Looking at this study, many anti-creatine protagonists will stand up cheering. But hold on. This is not how you judge a supplement, or for that matter anything. What one needs to understand from the above study is:

- This study only had one patient, who was not called in for any creatine testing, but had an adverse reaction from creatine intake.
- Having an adverse reaction to something doesn't mean, that substance is bad. One could get an adverse reaction from anything. The person may be sensitive or allergic to it.
- Worse, market is full of fake supplements, which have extremely toxic substances added to them. It may be a fake supplement, which may have caused the reaction, as there was no assessment of the supplement as such.

- No other study, even long term has proven creatine to be counterproductive for human intake, and in fact, has labelled creatine to be safe for kidneys.
- Even the researchers in the above study found that, extensive research over the last decade has shown creatine to be a safe oral supplement.
- The patient was well within the normal creatine intake, and had not overdosed it anytime.
- The researchers also recommend that people with kidney disease should avoid it, not normal people.

2. A study, examined the effects of high-dose of short term creatine supplementation (5gm/kg/day for 1 week) and long term creatine supplementation (1gm/kg/day for 4-8weeks) on liver and kidney in sedentary and exercised rats. The study showed mixed results: the long term creatine supplementation (4-8weeks) may adversely affect kidney and liver structure and function of sedentary rats. But no such effect was seen in exercising rats.

3. In a study, the participants were given either creatine (20gm/day for 5 days followed by 5gm/day throughout the trial) or a placebo for 12 weeks. All the participants underwent resistance training throughout the period and ate a high-protein diet. After 12 weeks there was no effect on kidney function of the subjects taking creatine.

4. A study, assessed the effects of creatine supplementation on kidney function in type-2 diabetic patients. The patients were allocated to randomly have creatine or a placebo for 12 weeks. All the patients were exercising during the study.

   The study found no effect of creatine supplementation on the kidney function of the diabetic patients, which opens up a new window for research, for the therapeutic use of creatine on diabetic patients.

5. In another study, performed on the postmenopausal women (age, 58±3years), researchers gave either creatine (20gm/day for 1 week and 5gm/day thereafter) or a placebo for 12 weeks. Again there was no effect seen on the kidney function or filtration rates of these women.

6. Acc. to a study, supplementation with large doses of creatine may falsely elevate creatinine concentrations. The study of research papers on creatine between 1996 and 2004, was carried out.

   The study found that, because creatine is converted to creatinine in the body, supplementation with large doses of creatine may falsely elevate creatinine concentrations. Creatinine levels were minimally affected by long term creatine supplementation.

7. A short term study, assessed the effects of creatine supplementation on a person with single kidney. A 20yr old man was given creatine supplementation for 35 days (20gm/day for 5 days followed by 5gm/day for next 30days). There was no effect of short term creatine supplementation on a person even with a single kidney.

8. A study, concluded that majority of the clinical studies fail to find an increased incidence of side effects with creatine supplementation. Studies have not found clinically significant deviations from normal values in renal, hepatic, cardiac or muscle function. Researchers also found that creatine has no adverse effects on renal health in individuals ingesting creatine supplements for up to five years.

9. A study, analysed the long term effects (10 months – 5 years) in a control group. They found that neither short term, or medium term, nor long term oral creatine supplementation induced detrimental effects on the kidney of healthy individuals.

10. A study (https://bit.ly/303Qep6), evaluated the effects of creatine supplementation (10gm/day) on renal function in healthy sedentary males (18-35year old) submitted to exercise training for 3 months. High dose of creatine supplementation over 3 months did not provoke any renal dysfunction in healthy males undergoing aerobic training.

11. A study, investigated the effect of prolonged creatine ingestion on renal function in rats with normal kidney function or pre-existing kidney failure. Creatine supplementation does not impair kidney function in animals with pre-existing renal failure or in control animals.

12. A study, suggested that, according to the existing literature, creatine supplementation appears safe when used by healthy adults at the recommended loading (20gm/day for five days) and maintenance doses (3gm/day). In people with a history of renal disease or those taking nephrotoxic medications, creatine may be associated with an increased risk of renal dysfunction. Also, since creatine supplementation may increase creatinine levels, it may act as a false indicator of renal dysfunction.

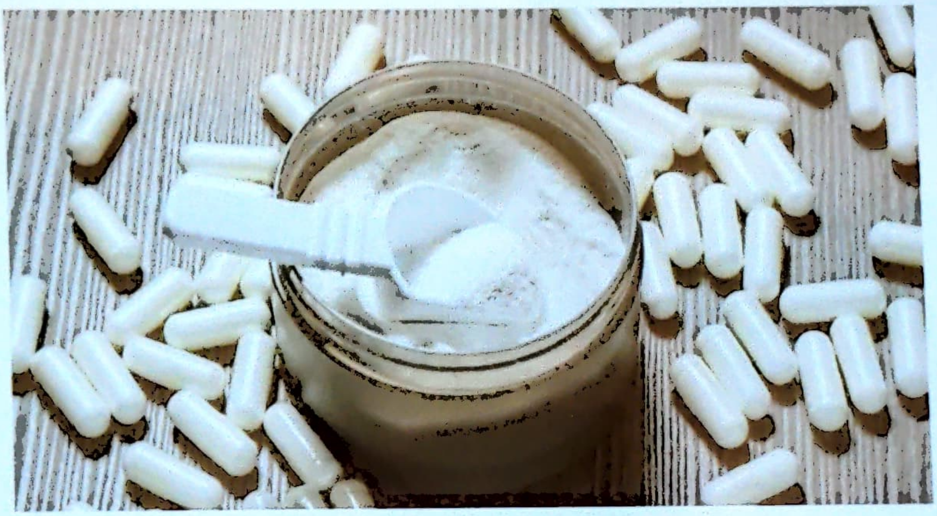
Though animal studies have supported the use of creatine even with renal diseases, but the overall studies are not well clear. There are studies which label creatine to be safe, but don't support the use of creatine in people with

renal disease. Creatine should be used with caution in people with renal disease.

Conclusion: both short and long term studies, with low, medium and large doses of creatine have proven creatine to be a safe supplement for people with normal kidney function. People with pre-existing kidney disease, may need to consult their physicians before administering creatine. It would be better to use creatine with workouts. Taking creatine while resting on your couch may just make you a better couch potato and nothing more.

The K School

IS CREATINE LOADING NECESSARY?



If you eat a regular diet containing meat and fish, your muscle stores of creatine are likely only 60–80% full. However, it's possible to maximize your creatine stores by using supplements. Trainers normally recommend a creatine loading phase to rapidly maximize your muscle stores. During this phase, you consume a relatively large amount of creatine in a short period to rapidly saturate your muscles.

A common doubt regarding creatine supplementation, is whether we need to load creatine. Everyone has a different understanding of this concept, but let's get the answer through proper research and evidence.

A common misconception regarding creatine supplementation is that individuals must 'load' with creatine to increase intramuscular creatine stores and subsequently experience the purported ergogenic benefits of creatine supplementation. However, lower daily creatine supplementation dosing strategies (i.e., 3-5g/day) are well established throughout the scientific literature for increasing intramuscular creatine stores leading to

greater improvements in muscle mass, performance and recovery compared to placebo.

1. Researchers studied, the effect of dietary creatine supplementation on skeletal muscle creatine accumulation and subsequent degradation and on urinary creatinine excretion in 31 male subjects who ingested creatine in different quantities over varying time periods.

   The researchers saw that the muscle total creatine concentration increased by 20% after 6 days of creatine supplementation at a rate of 20g/day. This elevated concentration was maintained when supplementation was continued at a rate of 2g/day for a further 30 days.

   However, in the absence of 2g/day supplementation, total creatine concentration gradually declined, such that 30 days after the cessation of supplementation the concentration was no different from the pre-supplementation value. During this period, urinary creatinine excretion was correspondingly increased.

   A similar, but more gradual, 20% increase in muscle total creatine concentration was observed over a period of 28 days when supplementation was undertaken at a rate of 3g/day.

   In conclusion, a rapid way to "creatine load" human skeletal muscle is to ingest 20g of creatine for 6 days. This elevated tissue concentration can then be maintained by ingestion of 2g/day thereafter.

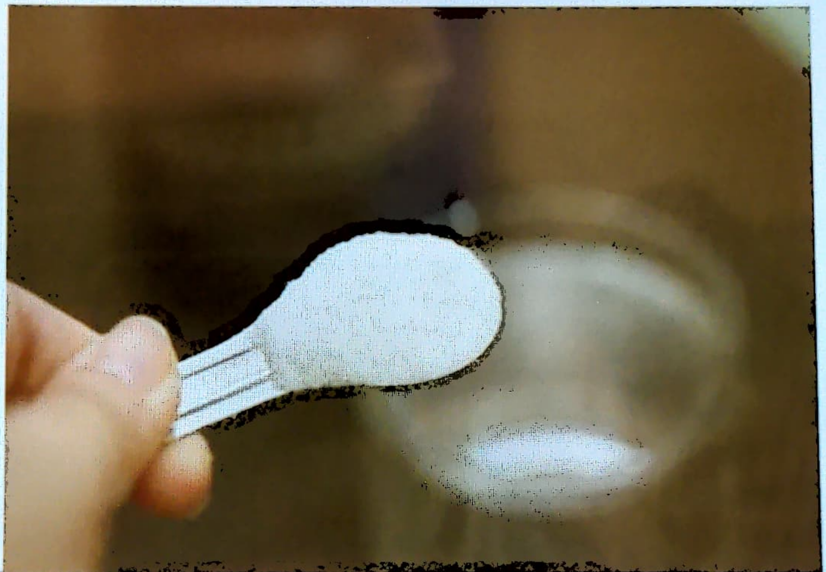
   On the other hand, the ingestion of 3g creatine/day is in the long term likely to be as effective at raising tissue levels as this higher dose.

2. A study, determined the impact of 3 different creatine loading procedures on skeletal muscle total Creatine accumulation and, second, to evaluate the effectiveness of 2 maintenance regimes on retaining intramuscular total creatine stores, in the 6-weeks following a 5-day creatine loading program (20g/day).

   Eighteen physically active male subjects were divided into 3 equal groups and administered either: (a) Creatine, (b) Glucose+Creatine, or (c) Creatine in conjunction with 60 min of daily muscular (repeated-sprint) exercise. Following the 5-day loading period, subjects were reassigned to 3 maintenance groups and ingested either 0g/day, 2g/day or 5g/day of Creatine for a period of 6 weeks.

   The data suggests that Glucose+Creatine is potentially the most effective means of elevating Total creatine accumulation in human skeletal muscle.

   Furthermore, after 5 days of Creatine loading, elevated muscle Total creatine concentrations can be maintained by the ingestion of small daily Creatine doses (2-5g) for a period of 6-weeks and that Total creatine concentrations may take longer than currently accepted to return to baseline values after such a Creatine loading regime.



3. A study, assessed the effects of both creatine loading and prolonged supplementation on muscle creatine content, body composition, muscle and whole-body oxidative capacity, substrate utilization during exercise, and on repeated sprints, as well as endurance-type time-trial performance on a cycle ergometer.

   Twenty subjects ingested creatine or a placebo during a 5-day loading period (20g/day) after which supplementation was continued for up to 6 weeks (2g/day). Creatine loading increased muscle free creatine, creatine phosphate and total creatine content.

   The study found that, the increase in body mass following creatine loading was maintained after 6-weeks of continued supplementation and accounted for by a corresponding increase in fat-free mass.

4. A study, examined the effects of 5-days of creatine loading on the fatigue threshold in 15 college-aged women, as compared to a placebo. The study found that 5 days of Creatine loading in women

may be an effective strategy for delaying the onset of neuromuscular fatigue during cycling.

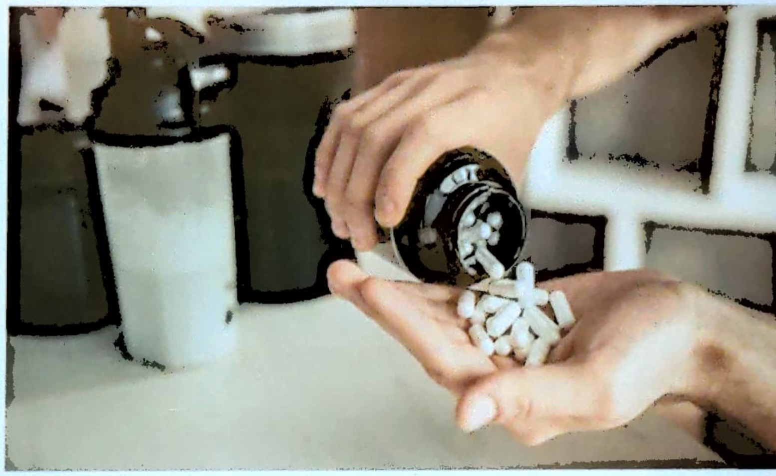
5. A study, established the effects of 2 and 5 days of creatine loading, coupled with resistance training, on muscular strength and anaerobic performance in trained athletes.

   Seventeen trained men were randomly assigned to a creatine or a placebo group. The creatine supplementation group consumed 20g of creatine per day (4 doses of 5g/day), whereas the placebo group was given a placebo similar in appearance and taste over the 5-day supplementation duration.

   The study found that a 5-day creatine loading regime coupled with resistance training resulted in significant improvements in both average anaerobic power. However, 2 days of supplementation was not sufficient to produce similar performance gains as that observed at the end of 5 days of loading in trained men, despite increases in creatine uptake in the body. The standard 5-day loading regime should hence be prescribed to individuals supplementing with creatine for enhanced strength and power.

6. A study, examined the effects of gender and creatine loading in anaerobic running capacity. Fifty trained men and women were selected and tested for 3 days. VO2 max was tested on a treadmill. The participants were divided into creatine or placebo group, and received 20 packets of creatine or 20 packets of placebo. They consumed 4 packets daily for 5 consecutive days.

   The study found that the creatine loading group exhibited 23% higher anaerobic running capacity than the placebo group. These changes were though not observed in women.



7. A study, suggested that, in a normal diet that contains 1-2g/day of creatine, muscle creatine stores are about 60-80% saturated. Therefore, dietary supplementation of creatine serves to increase muscle creatine by 20-40%. The **most effective way to increase muscle creatine** stores is to ingest 5g of **creatine monohydrate** (or approximately 0.3 g/kg body weight) four times daily for 5-7 days.

   However, higher levels of creatine supplementation for longer periods of time may be needed to increase brain concentrations of creatine, offset creatine synthesis deficiencies, or influence disease states. Once muscle creatine stores are fully saturated, creatine stores can generally be maintained by ingesting 3-5g/day, although some studies indicate that larger athletes may need to ingest as much as 5-10g/day in order to maintain creatine stores.

   An alternative supplementation protocol is to ingest 3g/day of creatine monohydrate for 28 days. However, this method would only result in a gradual increase in muscle creatine content compared to the more rapid loading method and may therefore have less effect on

> exercise performance and/or training adaptations until creatine stores are fully saturated.
>
> Research has shown that once creatine stores in the muscle are elevated, it generally takes 4–6 weeks for creatine stores to return to baseline. Additionally, it has been recommended that due to the health benefits of creatine, individuals should consume about 3g/day of creatine in their diet particularly as one ages

With all the above studies, creatine loading proves to be beneficial, but the question is that who needs this extra benefit. Do you need to load creatine? May be or maybe not. If you want to see the results extremely fast, you may undergo a loading protocol. But even taking a maintenance dose every day, will fully saturate your muscles within a month.

Even in the above studies, creatine loading was tested mostly against a placebo. Yes, it will work. But if you test creatine loading against someone who is taking normal creatine dose for a long time, the effects would be the same. Studies also showed that as you age, taking normal doses of creatine would be better than large doses for loading.

You do not *need* to load creatine. Many studies use either a straight dose of 5-10g daily, or even smaller amounts (2-3g). These studies also note benefits with creatine supplementation. This method is called 'Just taking creatine'.

Creatine loading will cause faster saturation of muscles with creatine, and can cause greater *acute* increases in strength and body weight (via water retention). This may also confer a psychological benefit, since you can 'see' yourself getting bigger. Taking a smaller dose for a longer period of time will eventually reach the same saturation point, but will take longer. The differences at the end of a cycle, should you choose to end the cycle, would be minimal.

There is another way suggested is 'Cycling' creatine. Cycling protocols involve the consumption of "loading" doses for 3–5 days every 3 to 4 weeks. These cycling protocols appear to be effective in increasing and maintaining muscle creatine content before a drop to baseline values, which occurs at about 4–6 weeks.

Once your creatine stores are saturated, there is a phase of creatine maintenance. The goal of maintenance is to find the lowest daily dose required to optimize creatine stores and benefits of supplementation while reducing potential side-effects of loading, like intestinal and gastric distress.

A maintenance phase of 2g daily appears to technically preserve creatine content in skeletal muscle of responders either inherently or after a loading phase, but in sedentary people or those with light activity, creatine content still progressively declines (although it still higher than baseline levels after six weeks) and glycogen increases seem to normalize. This maintenance dose may be wholly insufficient for athletes, a 5g maintenance protocol may be more prudent.

CAN YOU TAKE CREATINE & CAFFEINE TOGETHER?

There has been a lot of controversy and confusion about whether creatine and caffeine be combined for a better ergogenic effect. Some earlier studies suggested that creatine and caffeine oppose each other, primarily because coffee is a diuretic and creatine has a property of holding water in the muscles.

This entire confusion actually stems from a single study.. The study involved two groups, one consuming both creatine and caffeine together, and one consuming creatine alone. The results showed that the creatine-only group experienced modest improvements in overall performance during bouts of intermittent exercise, but there was no improvement seen in the group taking both creatine and caffeine.

But there were a number of issues with the study. Firstly, the study only looked at overall training performance and did not examine the actual creatine uptake into the muscles. Just because, one group performed better

only on caffeine, that does not mean, in any way that caffeine was negating the effects of creatine in the other group. Second issue was that there is no study after this single study, which proved the same.

To understand the confusion, it has been already proven in number of studies and is part of my book on coffee that caffeine is a very weak diuretic, and these properties of creatine and caffeine have nothing to do with their effectiveness as an ergogenic aid. The later studies have negated these controversies and shown that creatine and caffeine combined can be a good ergogenic aid.

A study, took fourteen male subjects, who did a high intensity running workout on a treadmill. These runners were given a mixture of creatine and caffeine. The study concluded that the combination of creatine and caffeine can be more ergogenic than either of them taken alone.

A study, investigated the effects of a pre-workout supplement containing creatine, caffeine and amino acids, on aerobic and anaerobic performance. Researchers saw that participants who took the pre-workout combination showed an improvement in anaerobic power, but no effect on aerobic power.

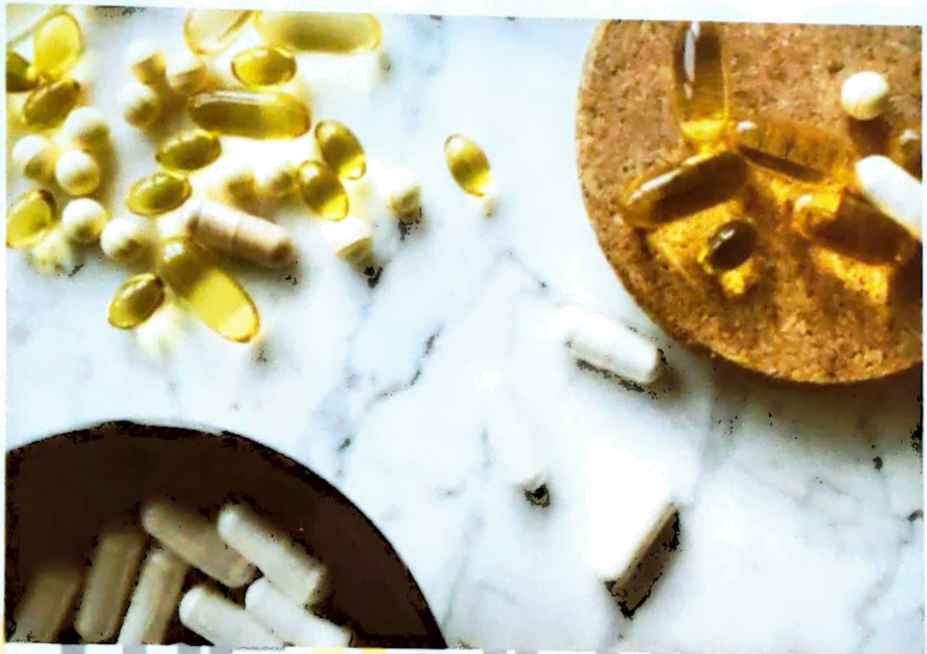
A study, investigated the effect of acute caffeine ingestion on intermittent high intensity sprint performance after 5 days of creatine loading, on 12 active men. The study determined that caffeine ingestion after creatine supplementation augmented the high intensity sprint performance.

A study, gave 6mg/kg caffeine and 3 grams of creatine to 16 male athletes. The results showed that, caffeine potentiates the effects of creatine during resistance training. So, combining caffeine with creatine for workout could be a better performance booster than only creatine or caffeine.

So, all those who want to mix their aromatic coffee with creatine powder or capsules, can safely and effectively do it, anytime they want.

The K School

IS TAKING ALA WITH CREATINE – BETTER ?



A study, determined the effect of alpha-lipoic acid on human skeletal muscle creatine uptake by directly measuring intramuscular concentrations of creatine, phosphocreatine, and adenosine triphosphate when creatine monohydrate was co-ingested with alpha-lipoic acid.

16 male subjects ingested 20gm/d of creatine monohydrate, 20gm/d of creatine monohydrate + 100gm/d of sucrose, or 20gm/d of creatine monohydrate + 100gm/d of sucrose + 1000mg/d of alpha-lipoic acid, for 5 days.

There was a significant increase in total creatine concentration following creatine supplementation, with the group ingesting alpha-lipoic acid showing a significantly greater increase in phosphocreatine and total creatine. These findings indicate that co-ingestion of alpha-lipoic acid with

creatine and a small amount of sucrose can enhance muscle total creatine content as compared to the ingestion of creatine and sucrose or creatine alone.

This is the only study till date on the combination of creatine and ALA. This was also done during the loading phase, the efficacy of which itself has been questioned. As far as its effects on body composition and metabolic health are concerned the additional provision of alpha lipoic acid does not necessarily translate into visible (muscle size & body fat) or (intramuscular fat) improvements.

So, the bottom line is, that there is no harm in taking ALA with creatine, as ALA itself is a good supplement. But the benefits aren't proven yet in combination.

ALA itself has multiple benefits, especially in the older adults, and the same we saw with creatine too. So, if older adults want to combine them or take them in isolation, they surely would benefit.

But the same may not be a good option for other individuals. Also, adding more supplements simply means, spending more money. The ALA+Creatine combo may not be very pocket friendly option for most people, not forgetting the fact that creatine itself is quite reasonably priced.

IS CREATINE SAFE FOR LONG-TERM USE?

A large body of human and animal research suggests that creatine does have a consistent ergogenic effect, particularly with exercises or activities requiring high intensity short bursts of energy. Human data are primarily derived from three types of studies: acute studies, involving high doses (20gm/d) with short duration (< or = 1 week), chronic studies involving lower doses (3-5gm/d) and longer duration (1 year), or a combination of both.

Multiple studies, both short and long term, have clearly proven the long term efficacy and safety of creatine intake.

A study showed that, long-term creatine supplementation (up to 21-months) does not appear to adversely affect markers of health status in athletes undergoing intense training in comparison to athletes who do not take creatine.

Many anecdotal claims of side effects including dehydration, cramping, kidney and liver damage, musculoskeletal injury, gastrointestinal distress,

and anterior (leg) compartment syndrome still exist in the media and popular literature.

We have already seen above that creatine supplementation doesn't affect the kidneys, muscle injury or cause cramping. Over the last few years a number of researchers have begun to release results of long-term safety trials. So far, no long-term side effects have been observed in athletes (up to 5 years), infants with creatine synthesis deficiency (up to 3 years), or in clinical patient populations (up to 5 years).

In addition, research has demonstrated a number of potentially helpful clinical uses of CM in heart patients, infants and patients with creatine synthesis deficiency, patients suffering orthopaedic injury, and patients with various neuromuscular diseases. Potential medical uses of supplemental creatine have been investigated since the mid 1970s.

Even in patients with neuromuscular disorders, of ages over app. 55yr, long term intake of creatine (10gm/day for 310 days), very few and minor side-effects like water retention, cramps and nausea, were seen. Creatine was found to be absolutely safe and effective for them.

In a similar study, 40 elderly patients with Parkinson's Disease, were given 4gm/d creatine monohydrate for a period of 2 years. The creatine was well tolerated during the entire period by all patients, and no major side-effects were observed.

Now, with all the above and more evidence, it's clear that creatine is absolutely safe, both for long and short term use, in both large and small doses. But, with this rising another question. If creatine hasn't shown any side effect even in the long run, then do we need to cycle creatine, or in simple terms, for how long can we use creatine without any side effects?

Before we move ahead, let's understand what we mean by cycling a supplement. It simply means, taking a supplement for a particular time, and then stopping entirely for a time. It is believed that, with such a strategy, the effectiveness of the supplement will increase, and the body will not get used to it, or develop a tolerance against it.

Therefore, in such a case, you either stop taking the compound immediately, or stop it temporarily and began again, after sometime, a way of cycling. This gives your body a chance to decrease the tolerance.

However, with creatine, there is never been a study, which prevents it's long term continuous use. The body doesn't reduce the production and storage of natural creatine.

Creatine is mostly synthesized in the liver. Supplementation of creatine will suppress subsequent production of creatine in the body, since high levels of creatine will suppress its own synthesis, by downregulating the enzymes of synthesis. This is a reversible suppression.

Therefore, there is ideally no use of cycling creatine, or stop using it, unless you have a reason to stop your workout. The same amount of creatine use will give you the same amount of energy years from now as it did the 2nd week into using it.

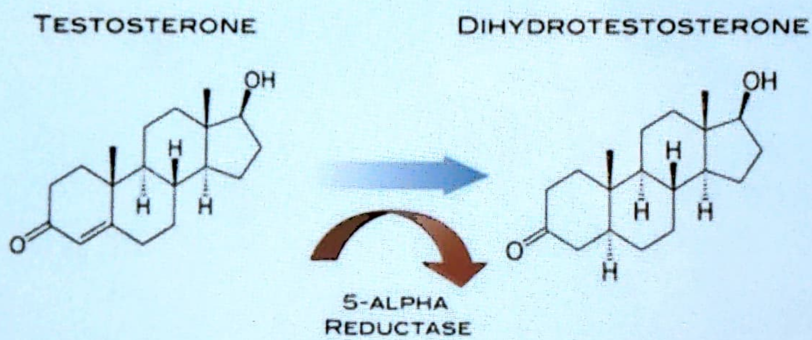
Should you decide to stop creatine for any reason, you will experience no side effects. All muscle built while using creatine will remain, and your work out will remain effective. You may notice a gradual decrease of exercise effectiveness, though it will simply return to your pre-creatine results, and no worse.

CREATINE & HAIR LOSS

The entire cause of creatine & hair loss, has stemmed from one study. Where college-aged male rugby players who supplemented with creatine (25g/day for 7 days, followed by 5g/day thereafter for an additional 14 days) experienced an increase in serum dihydrotestosterone (DHT) concentrations over time. Specifically, DHT increased by 56% after the seven-day loading period, and remained 40% above baseline values after the 14-day maintenance period. These results were statistically significant compared to when the subjects consumed a placebo (50g of glucose per day for 7 days, followed by 30g/day for 14 days thereafter).

Given that changes in these hormones, particularly DHT, have been linked to some (but not all) occurrences of hair loss/baldness. However, the issue is that, the above study has never been replicated and that intense resistance exercise itself can cause increases in these androgenic hormones.

DHT, is a metabolite of testosterone and a sex steroid found in the body. When testosterone gets converted into dihydrotestosterone (DHT) it becomes many times stronger than testosterone. DHT is the most potent steroid found in the human body. DHT is formed when testosterone interacts with enzyme called 5-Alpha Reductase.



The enzyme 5-alpha-reductase is found in abundance in tissues like prostate, skin, scalp, liver and the Central Nervous System. In males, DHT can bind to androgen receptors in susceptible hair follicles and cause them to shrink, ultimately leading to hair loss.

However, in the above study also, while we saw that creatine supplementation upregulated 5-alpha-reductase activity in these males (potentially leading to increased formation of DHT), but there wasn't any reported hair loss/baldness in subjects. Also there was no increase in total testosterone seen in these subjects.

Other than the above study, there have been studies which showed an increase in testosterone after taking creatine (https://bit.ly/3H6f48W), (https://bit.ly/3FgCUgP), (https://bit.ly/3mZkwmd). But none of these studies, reported any hair loss after the rise in test levels, as test levels and DHT levels will fluctuate, due to many other reasons also.

But then there are many studies which reported no increase in testosterone levels after creatine intake (https://bit.ly/3C36eVT), (https://bit.ly/307Of3R), (https://bit.ly/31Nbbpq), (https://bit.ly/3BV6S7X), (https://bit.ly/3C24M6f).

"*Before we conclude, we need to mention three caveats.* ***First,*** *these studies were all conducted in healthy young males, and all but one in athletes or other trained individuals.* ***Second,*** *in the one study that looked at DHT and noted an increase, DHT stayed well within normal range; so even if creatine increases DHT, it still may not cause greater loss of hair than would otherwise occur.* ***Third,*** *and most important: the effect of creatine supplementation on hair loss hasn't been directly studied, so all we can make are educated guesses".*

To this day, no studies have *directly* examined creatine's effects on hair loss.

WHAT IS THE BEST TIME TO TAKE CREATINE?

For the answer to the best time to take creatine, there have been mainly two types of prescriptions from various coaches or supplement dealers:

- **Pre Workout** – which is due to the argument that it will increase strength and power output during the workout.
- **Post Workout** – this argument was based on the age-old concept of enhanced nutrient absorption post-workout, so creatine would be absorbed better.

A study, tested the best time to take creatine intake, on 19 male bodybuilders. Subjects were assigned to one of the following groups: PRE-SUPP or POST-SUPP workout supplementation of creatine (5 grams). The PRE-SUPP group consumed 5 grams of creatine immediately before exercise. On the other hand, the POST-SUPP group consumed 5 grams immediately after exercise. Subjects trained on average five days per week for four weeks. Subjects consumed the supplement on the two non-training days at their convenience.

The study concluded that creatine supplementation plus resistance exercise increases fat-free mass and strength. Based on the magnitude inferences it appears that consuming creatine immediately post-workout is superior to pre-workout vis a vis body composition and strength.

However, the problem with this study was that the difference observed was extremely little, which actually means that the timing didn't matter. When the study was broken down on a case-by-case basis, they did not find any significant differences between the groups, but they did find a trend that suggested that there *may* be a difference.

Another study, compared the effects of creatine supplementation before vs. after supervised resistance training in healthy older adults as compared to a placebo. Participants were divided into one of two groups: Resistance training (RT) was performed 3 days/week, on non-consecutive days, for 12 weeks.

Over the 12-week training period, both groups experienced a significant increase in whole-body lean tissue mass, limb muscle thickness, and upper and lower body strength and a decrease in muscle protein catabolism, with no differences between groups. Changes in muscle mass or strength were seen to be similar when creatine was ingested before or after supervised resistance training in older adults.

In a study, researchers studied creatine intake timings in older adults (50-71 years), as compared to a placebo. They found that Creatine supplementation, independent of the timing of ingestion, increased muscle strength more than placebo. However, the researchers also suggested that creatine supplementation in close proximity to resistance training may be an important strategy for increasing muscle mass and strength.

A study, suggested that, creatine ingested before and after resistance training sessions appears to be an effective strategy to increase muscle mass and strength, with slightly greater benefit if, creatine is consumed post exercise compared to pre-exercise.

Acc. to a study, increased blood flow due to exercise effects creatine uptake and retention. Creatine peaks <2h after ingestion and remains elevated for app. 4h while blood flow may return to baseline within 30 min after exercise. Based on this mechanisms, creatine before exercise may be ideal.

Exercise can also modulate the Na+-K+ pump activity, which is another mechanism to justify the theoretical importance of creatine timing. Exercise-mediated upregulation of skeletal muscle Na+-K+ pump activity may contribute to creatine transport and subsequent creatine accumulation in muscle.

Similar to the effects on increased blood flow, pre-exercise creatine supplementation and elevated concentration in circulation could coincide with maximal Na+-K+ pump activation during exercise, though the latter may last for much longer periods, meaning that post-exercise creatine may pr~~ovide muscle benefits~~ from the same mechanism.

In addition, there is evidence to suggest that chronic exercise may upregulate the Na+-K+ pump activity, suggesting that exercise per se may be key to optimizing increases in muscle creatine stores, however, in theory, creatine ingested in close proximity to training (immediately before and/or after sessions) may be ideal.

A study, investigated the effects of pre- vs. post-exercise creatine monohydrate supplementation on resistance training adaptations and body composition. 34 healthy resistance-trained male and female athletes were assigned to consume a placebo, or 5g dose of creatine monohydrate within 1h before training, or within 1h after training for 8 weeks, while completing a weekly resistance training program. Participants co-ingested 25-gram doses of both whey protein isolate and maltodextrin along with each assigned supplement dose.

All groups experienced similar and statistically significant increases in fat free mass, upper and lower body strength, and decreases in body mass, fat mass, and percent body fat. The timing of creatine monohydrate did not exert any additional influence over the measured outcomes.

I couldn't find any study which dictates the best time to take creatine intake conclusively. As a final conclusion, I would suggest, that creatine can be taken anytime, better would be to take to near to your workout.

With this comes another doubt: **Do we need to take creatine on rest/non-workout days?**

There is no study or consensus on this part, as some people say that we should take creatine every day, irrespective of the day. Taking creatine on off days, will help keep the creatine levels elevated.

But there is no basis of this statement, or there isn't a study suggesting that taking creatine on rest days will keep creatine levels in body elevated, and thus lead to increase in performance.

As, the best time to take creatine has already proven to be before/after the workout. So, my suggestion would be to skip using creatine on rest days.

The K School

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DO WE NEED TO TAKE CARBOHYDRATES WITH CREATINE?

Studies have shown that co-ingestion of creatine with carbohydrate is known to increase glycogen accrual in skeletal muscle (possibly resulting in increased cell volume) although the creatine content in muscles does not appear to be significantly increased.

When determining how glycogen is influenced under supplementation of creatine, creatine supplementation appears to enhance the accumulation and synthesis of glycogen in skeletal muscle when co-ingested with carbohydrates.

Increasing glycogen replenishment rates with creatine supplementation does not appear to increase the amount of creatine that actually enters the cell.

Studies have shown that carbohydrate ingestion substantially augments muscle creatine accumulation during creatine feeding, which appears to be insulin mediated.

A study found that, administration of creatine + protein, amino acids, and carbohydrate can stimulate insulin release and augment whole-body creatine retention to the same extent as when larger quantities of simple sugars are ingested (https://bit.ly/3H5Evri).

A study, evaluated the effects of combined creatine and fenugreek extract supplementation on strength and body composition. They found that, creatine plus fenugreek extract supplementation had a significant impact on upper body strength and body composition as effectively as the combination of 5g of creatine with 70g of dextrose. Thus, the use of fenugreek with creatine supplementation may be an effective means for enhancing creatine uptake while eliminating the need for excessive amounts of simple carbohydrates.

A study, found that, the ingestion of creatine in conjunction with approximately 50g of protein and carbohydrates is as effective at potentiating insulin release and creatine retention as ingesting creatine in combination with almost 100g of carbs.

In another study, carbohydrate ingestion augmented creatine retention during creatine feeding and creatine retention was not further increased when exercise was performed prior to ingestion.

A similar study on swimmers concluded that, no performance advantage was gained from the addition of carbohydrate to a creatine-loading regimen in high-calibre swimmers.

A study, examined the effect of creatine supplementation on anaerobic performance when ingesting creatine and carbohydrates together. They

found that, ingesting creatine together with carbohydrates will not further improve performance compared to the ingestion of creatine only.

Then there are studies, which examined if creatine co-ingestion with carbohydrates or cinnamon extract improved anaerobic capacity, muscular strength, and muscular endurance. They found no added benefit in anaerobic power, strength, and endurance.
A similar study, compared the effects of an energy-free placebo, 2 different caloric concentrations of carbohydrate drinks, and a creatine monohydrate supplement on repeated jump heights. The 250-kcal carbohydrate-supplemented group experienced a level of benefit that was at least equal to that of the Creatine group, suggesting that the higher dose of carbohydrate was as effective as Creatine in maintaining repeated bouts of high-intensity activity as measured by repeated static jumps.

Yet another study, determined if a creatine supplement prevents the decrease in performance while consuming a low carbohydrate diet during high-intensity exercise. The results of the study demonstrated that a creatine loading protocol attenuates the fatigue associated with consuming a diet low in carbohydrate content, and indeed, leads to an improvement in high-intensity interval exercise performance.

Conclusion: it's a tad confusing, as most studies prove that taking carbs+creatine will increase muscle creatine accumulation. But then there are studies which prove that this addition of carbs to creatine is not actually helping in improving performance, when compared to creatine alone.

On the other hand, eating protein+carbs+creatine helps a bit more than carbs & creatine consumed alone.

Also, we saw above that the best time to take creatine, would be around your workout, pre or post.

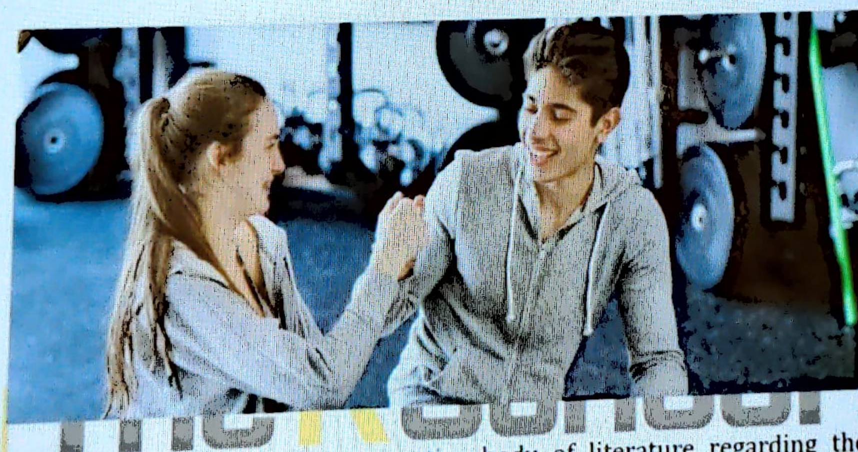
So, if you are taking a post workout whey concentrate, you can simply add 5gm of creatine in it.

Or, just take creatine with your post-workout meal, which has a balance of carbs and proteins.

Or, you can also take it pre-workout with a carbohydrate source, you would consume to derive energy for the workout.

IS CREATINE SAFE FOR CHILDREN?

This may be one of the biggest concerns related to creatine intake. Whether children (<19yrs) can consume creatine as a supplement. We have already seen the safety aspects of creatine supplementation in adults, and found that, both short and long term intake of creatine is safe and well tolerated. But does the same applies to kids?



Despite the overwhelming supportive body of literature regarding the efficacy of creatine supplementation in adult athletes, limited data are available in adolescent athletes. This lack of available literature is likely attributable to ethical restrictions, safety concerns and methodological challenges.

While fewer investigations have been conducted in using younger participants, no study has shown CM to have adverse effects in children. In fact, long-term CM supplementation (e.g., 4 – 8 grams/day for up to 3 years) has been used as an adjunctive therapy for a number of creatine synthesis deficiencies and neuromuscular disorders in children.

Younger athletes should consider a creatine supplement only if the following conditions are met:

1. The athlete is past puberty and is involved in serious/competitive training that may benefit from creatine supplementation;
2. The athlete is eating a well-balanced, performance-enhancing diet;
3. The athlete and his/her parents understand the truth concerning the effects of creatine supplementation;
4. The athlete's parents approve that their child takes supplemental creatine;
5. Creatine supplementation can be supervised by the athletes parents, trainers, coaches, and/or physician;
6. Quality supplements are used; and,
7. The athlete does not exceed recommended dosages.

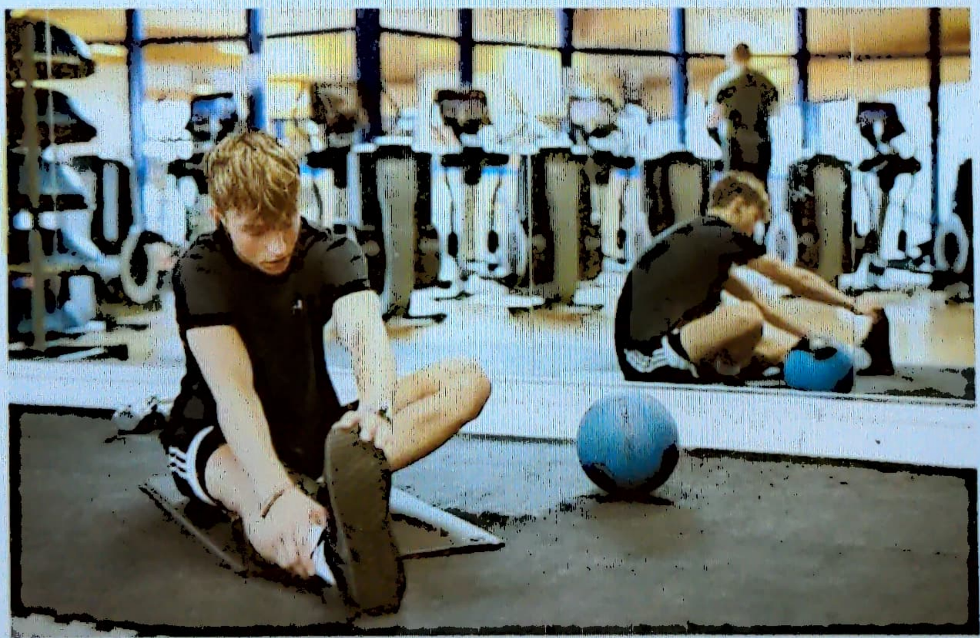
If these conditions are met, then it would seem reasonable that high school athletes should be able to take a creatine supplement. Doing so may actually provide a safe nutritional alternative to illegal anabolic steroids or other potentially harmful drugs.

From a clinical perspective, creatine supplementation has been found to potentially offer health benefits with minimal adverse effects in younger populations.

Multiple studies have not just shown the tremendous benefits of creatine use in medical conditions, but also proven its safety. A study examined the efficacy and safety of creatine supplementation in childhood systemic lupus. Researchers found improvements in paediatric patients with systemic lupus erythematosus and reported no adverse changes in laboratory parameters of haematology, kidney function, liver function or inflammatory markers after 12 weeks of creatine supplementation.

Another study, found that, four months of creatine monohydrate supplementation led to increases in FFM and handgrip strength in the dominant hand and a reduction in a marker of bone breakdown and was well tolerated in children with muscular dystrophy.

A similar study, found that the administration of creatine to children with Traumatic brain injury, improved results in several parameters, including duration of post-traumatic amnesia, duration of intubation, intensive care unit (ICU) stay, disability, good recovery, self-care, communication, locomotion, sociability, personality/behaviour and neuro-physical, and cognitive function. No side effects were seen because of creatine administration.



Further, several of these clinical trials implemented strict clinical surveillance measures, including continual monitoring of laboratory markers of kidney health, inflammation, and liver function; none of which

were negatively impacted by the respective creatine supplementation interventions. These findings support the hypothesis of creatine supplementation likely being safe for children and adolescents.

In 2020, the US FDA, classified creatine as generally recognized as safe (GRAS). This classification indicates that the currently available scientific data pertaining to the safety of creatine, is sufficient and has been agreed upon by a consensus of qualified experts, thereby determining creatine to be safe under the conditions of its intended use.

Creatine has shown tremendous benefits in terms of enhancement in sports performance in young athletes:

- In a study, 18 male and female junior competitive swimmers supplemented their diets with 21gm/day of creatine monohydrate (Cr) or a maltodextrin placebo (P) for 9 days during training. Significant differences were observed among swim times, with Cr subjects swimming significantly faster than P subjects following supplementation.

- A study, investigated the effect of 21 days of creatine supplementation, at the rate of 20gm/day vs maltodextrin (placebo), on swimming performance, body composition and other variables, in 16 national junior competitive female swimmers. The study showed a significant difference in propelling efficiency and other variables. Though not much changes were seen in body composition.

- A study, determined the effects of 28 days of creatine supplementation during training on body composition, strength, sprint performance etc. in 25 young football players. Researchers found that, the addition of creatine to the glucose/taurine/electrolyte supplement promoted greater gains in fat/bone-free mass, isotonic lifting volume, and sprint performance during intense resistance/agility training.

- A research team, studied the efficacy of two dietary supplements on measures of body mass, body composition, and performance in 42 American football players, who received either creatine monohydrate, or calcium pyruvate, or a mix of both. The group which received creatine only, or both, showed significantly greater increases for body mass, lean body mass, 1 repetition maximum (RM) bench press, combined 1 RM squat and bench press, and static vertical jump (SVJ) power output.

- Another study, assessed the effects of a 9-wk regimen of creatine monohydrate supplementation coupled with resistance training on body composition and neuromuscular performance in 25 young football athletes. The Creatine group received 20gm/d of creatine for the first 5 d in 5g doses, four times daily, followed by 5gm/d for the remainder of the study. Each 5g dose was mixed with 500mL of glucose solution (Gatorade). The P group received a placebo (sodium phosphate monohydrate) following the exact protocol as the Cr group. The C group received no supplementation.

  The data indicated that there were significant increases in body weight and lean body mass for the treatment group (Cr) when compared with the other two groups after the training program, with little or no change in the percentage of body fat. Thus creatine, supplemented concurrently with resistance and anaerobic training, may positively affect cell hydration status and enhance performance variables further than augmentation seen with training alone.

- In a study, the effects of creatine and creatine plus Beta-alanine on strength, power, body composition, and endocrine changes were examined during a 10-wk resistance training program in collegiate football players. Thirty-three male subjects were randomly assigned to either a placebo, creatine, or creatine plus Beta-alanine group.

  Changes in lean body mass and percent body fat were greater in Creatine+beta-alanine compared to Creatine or Placebo. Significantly greater strength improvements were seen in Creatine+beta-alanine and Creatine compared to Placebo. Creatine plus beta-alanine supplementation appeared to have the greatest effect on lean tissue accruement and body fat composition.

- A study, determined if creatine supplementation during 8 weeks of a season of rugby union football can increase muscular performance, without negatively affecting aerobic endurance. Rugby players were randomized to receive 0.1mg/kg/day creatine monohydrate or

placebo during 8 weeks of the rugby season. Players practiced twice per week for approximately 2 h per session and played one 80 min game per week.

The group receiving creatine supplementation had a greater increase in the number of repetitions for combined bench press and leg press tests compared with the placebo group. There were no changes in either group for aerobic endurance. Thus, creatine supplementation during a rugby union football season is effective for increasing muscular endurance, but has no effect on body composition or aerobic endurance.

- A study, investigated the influence of oral supplementation with creatine monohydrate on muscular performance during repeated sets of high-intensity resistance exercise. Fourteen active men were assigned to either a creatine group (25gm/day) or a placebo group. Researchers found that, one week of creatine supplementation (25gm/day) enhances muscular performance during repeated sets of bench press and jump squat exercise.

- A study, determined the effects of creatine supplementation during short-term resistance training overreaching on performance, body composition, and resting hormone concentrations, 17 men were assigned to supplement with 0.3gm/kg/day of creatine monohydrate or placebo, while performing resistance exercise (5 days/week for 4 weeks).

Maximal squat and bench press and explosive power in the bench press were reduced during the initial weeks of training in Placebo but not Creatine. Explosive power in the bench press, body mass, and lean body mass (LBM) in the legs were augmented to a greater extent in Creatine by the end of the 6-week period. A tendency for greater 1-RM squat improvement was also observed in Creatine.

- Another study, examined the effects of acute creatine-monohydrate supplementation on soccer-specific performance in young soccer players. Twenty young male soccer players participated in the study.

  Specific dribble test times improved significantly in the creatine group after supplementation protocol. Sprint-power test times were significantly improved after creatine-monohydrate supplementation as well as vertical jump height in creatine trial. Furthermore, dribble and power test times, along with vertical jump height, were superior in creatine versus placebo trial.

- A study, determined the effects of a low dose, short-term Creatine monohydrate (Cr) supplementation (0. 03g/kg/day) on muscle power output in 19 elite youth soccer players. There were significant increases in power output after the Creatine supplementation period but not the placebo period. There were also significant increases in total work, but not Fatigue, after the Creatine supplementation and placebo periods.

- A study, determined whether creatine supplementation could improve mechanical power output, and swimming performance in highly trained junior competitive fin swimmers. Sixteen young male fin swimmers were randomly and evenly assigned to either a creatine or placebo group.

  The results of this study indicated that five day Creatine supplementation enhances the dynamic strength and may increase anaerobic metabolism in the lower extremity muscles, and improves performance in consecutive maximal swims in highly trained adolescent fin swimmers.

What is important to note is that, none of these studies observed any gastrointestinal discomfort or changes in hemodynamic, urine, or any blood markers of clinical health and safety following the supplementation periods.

Some critics of creatine supplementation have pointed to warnings listed on some product labels that individuals younger than 18 years of age should not take creatine as evidence that creatine supplementation is unsafe in younger populations. It's important to understand that this is a legal precaution and that there is no scientific evidence that children and/or adolescents should not take creatine. A number of short- and long-term studies using relatively high doses of creatine have been conducted in infants, toddlers and adolescents with some health and/or ergogenic benefit observed. These studies provide no evidence that use of creatine at recommended doses pose a health risk to individuals less than 18 years of age.

However, though there is no minimum age of taking creatine studied as of now, and even youngsters below 18, taking creatine, are also free of any side-effects. Therefore a consensus of 18yrs has been reached as the age for most youngsters who want to start taking creatine.

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IS CREATINE USEFUL FOR OLDER ADULTS?

One of the most common problems seen in older adults is age related sarcopenia. Sarcopenia (muscle failure) is characterised by a decline in skeletal muscle strength, mass and function. Primary sarcopenia occurs with advancing age, whilst secondary sarcopenia is secondary to co-existent illnesses, e.g., diabetes. The prevalence of sarcopenia increases with age and similar to osteoporosis has a multifactorial aetiology—undernutrition, decreased physical activity, inflammation, presence of comorbid diseases.

The biomechanical relationship of muscle and bone is evident during ageing where lower physical activity and mechanical loading contributes to both decreased muscle mass, function and bone mineral density.

In addition, as with caloric intake, dietary vitamin D and protein intake also diminishes with age, contributing to reduced muscle strength, lower bone mineralisation and an increase in falls risk. Osteosarcopenia represents an additive

burden for older people in terms of their physical and psychological health as well as their quality of life.

Sarcopenia further increases fracture risk through increasing risk of fall in patients who already have vulnerability of bones due to osteoporosis. On this basis, recently the term 'osteosarcopenia' has been proposed for patients with both sarcopenia and osteoporosis. Osteosarcopenia is a potentially preventable and treatable disease.

One of the most promising conditions that could benefit from creatine supplementation is age related sarcopenia. While resistance training is considered cornerstone in the treatment of sarcopenia, accumulating evidence indicates that creatine supplementation may enhance the anabolic environment produced by resistance training, subsequently mitigating indices of sarcopenia.

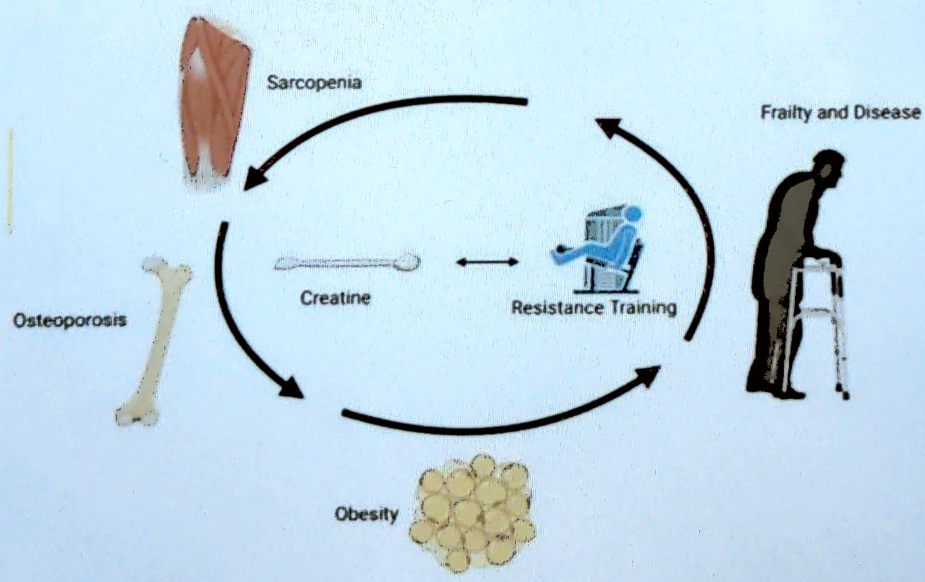
~~There is tons of research~~ on the psychological and physiological beneficial effects of creatine in the elderly. The well documented benefits of creatine supplementation in young adults, including increased lean body mass, increased strength, and enhanced fatigue resistance are particularly important to older adults. With aging and reduced physical activity, there are decreases in muscle creatine, muscle mass, bone density, and strength.

However, there is evidence that creatine ingestion may reverse these changes, and subsequently improve activities of daily living. Several groups have demonstrated that in older adults, short-term high-dose creatine supplementation, independent of exercise training, increases body mass, enhances fatigue resistance, increases muscle strength, and improves the performance of activities of daily living.

Similarly, in older adults, concurrent creatine supplementation and resistance training increase lean body mass, enhance fatigue resistance, increase muscle strength, and improve performance of activities of daily living to a greater extent than resistance training alone. Additionally,

creatine supplementation plus resistance training results in a greater increase in bone mineral density than resistance training alone.

Higher brain creatine is associated with improved neuropsychological performance, and recently, creatine supplementation has been shown to increase brain creatine and phosphocreatine. Subsequent studies have demonstrated that cognitive processing, that is either experimentally (following sleep deprivation) or naturally (due to aging) impaired, can be improved with creatine supplementation. Creatine is an inexpensive and safe dietary supplement that has both peripheral and central effects. The benefits afforded to older adults through creatine ingestion are substantial, can improve quality of life, and ultimately may reduce the disease burden associated with sarcopenia and cognitive dysfunction.

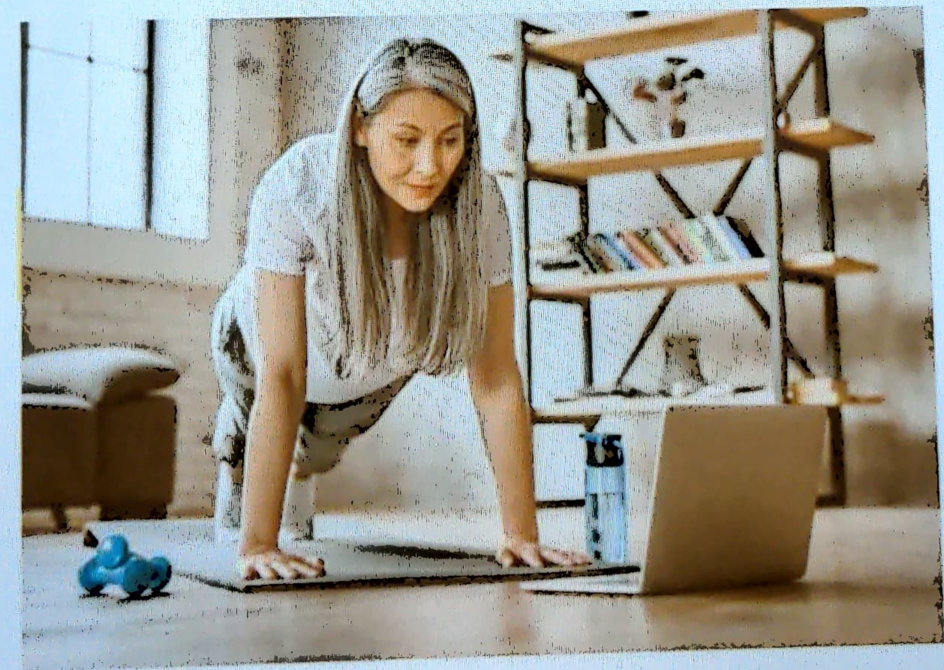


(Pic Source)

Similar review studies, have shown that that creatine supplementation increases muscle creatine, enhances fatigue resistance, increases

strength/power, increases fat free mass, and enhances functional performance in older adults. In addition to the beneficial effects of creatine supplementation on skeletal muscle in older adults, new data indicate a role of creatine in improving bone health and cognitive processing. Creatine supplementation, with or without concurrent resistance exercise, should be considered a safe and effective nutritional therapy to combat age-related changes in muscle.

The beneficial effect of creatine upon lean mass and muscle function appears to be applicable to older individuals regardless of sex, fitness or health status, although studies with very old (>90 years old) and severely frail individuals remain scarce.



As a possible countermeasure to sarcopenia and its age-related co-morbidities, Creatine (especially when combined with resistance

training) has some favourable effects on aging muscle, bone and fat mass, muscle and
bone strength, and physical performance, primarily in healthy populations. Independent of Resistance training, a creatine loading phase and/or high relative daily dosage of creatine (≥0.3g/kg) may be required to produce some muscle benefits in older adults. Creatine (independent of resistance training) for up to 2 years appears to provide no bone benefits in older females. The effects of Creatine alone on bone measures in older males is unknown.

A creatine-loading phase is important for older adults wanting to improve muscle strength. In addition to a creatine-loading phase, a lower daily dosage of creatine (≤5g) appears sufficient to improve upper-body strength. However, a higher daily dosage of creatine (>5g) after the loading phase is needed to increase lower-body strength. Regarding the effects of creatine ingestion frequency, creatine supplementation only on resistance training days significantly increased measures of lean tissue mass and strength compared to placebo.

Multiple other studies including systematic review and meta-analysis of randomized controlled trials have presented similar results both in older men and women (https://bit.ly/3qwhtnt), (https://bit.ly/2YCu6C0), (https://bit.ly/30eVozn), (https://bit.ly/3n8J642), (https://bit.ly/3DakVrC), (https://bit.ly/3CcSWWS), (https://bit.ly/3wDYSXE), (https://bit.ly/31Vrhxi), (https://bit.ly/3D8Lhdn), (https://bit.ly/3Fa5boY), (https://bit.ly/3C8ecx0), (https://bit.ly/3CcbvKK), (https://bit.ly/3wDt1Xa), (https://bit.ly/3wCaJFU), (https://shorturl.at/fmpCV), (https://bit.ly/3HfpYIK), (https://shorturl.at/bzERS).

IS CREATINE USEFUL FOR WOMEN ?

Though we have seen multiple studies above, which proves the efficacy of creatine in women, including post-menopausal women.

Despite widespread use and decades of research related to creatine, its effects in females are not well understood. Creatine characteristics vary between males and females. For example, females have/exhibit 70–80% lower endogenous creatine stores than males. Females have also been reported to consume significantly lower amounts of dietary creatine compared to males, indicating that females may benefit from creatine supplementation as a strategy/means to increase endogenous stores. Interestingly, females have higher reported (app. 10%) resting levels of intramuscular creatine concentrations compared to males which could theoretically lower their responsiveness to supplementation and require higher dosages compared to males.

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Creatine supplementation may be of particular importance during menses, pregnancy, post-partum, during and post-menopause. A considerable amount of evidence indicates that creatine is an effective ergogenic aid for increasing strength, power, and athletic performance in females without marked changes in body weight. The reluctance among females to use creatine may be due to a fear of weight gain or other adverse side effects, which are largely unfounded, particularly in women. This rapid weight gain is more prevalent among males; weight may rapidly and temporarily increase with a loading dose which reflects an increase in cellular hydration (i.e., water weight).

When reviewing the literature that has examined the effect of creatine supplementation on a variety of performance indices in females, the benefits firmly outweigh any associated risks or reported adverse events. The potential for adverse effects from creatine supplementation are largely unfounded.

A meta-analysis study clearly showed that, mortality and serious adverse events are not associated with Creatine supplementation in females. Nor does the use of creatine supplementation increase the risk of total adverse outcomes, weight gain or renal and hepatic complications in females.

There is substantial evidence to suggest that creatine supplementation is effective for increasing strength and power in both trained and untrained females, without large fluctuations in body weight. Females with varying levels of training and fitness may experience improvements in both anaerobic and aerobic exercise performance from both short-term and long-term creatine supplementation. Current research suggests creatine is an effective way to improve sport performance in females.

Increased metabolic demand from growth and development during gestation, particularly from the placenta, has been associated with a reduced creatine pool. Recent human data suggests a dramatic alteration in creatine homeostasis during pregnancy and a reduction in creatine stores

during pregnancy have been linked with low birth weight and pre-term birth. Although there are no human studies to date that have evaluated the effect of Creatine supplementation during pregnancy, Creatine supplementation could provide a safe, low-cost nutritional strategy for reducing intra- and post-partum complications associated with cellular energy depletion.

Maternal creatine supplementation during pregnancy in pre-clinical animal studies have demonstrated a protective effect against foetal death and organ damage associated with intrapartum hypoxia. Reduced creatine levels in late pregnancy have also been associated with low foetal growth. There is additional data that metabolic demand from the placenta during gestation further lowers the creatine pool of the mother, which may be associated with low birth weight and pre-term birth. Creatine supplementation during pregnancy has been shown to enhance neuronal cell uptake of creatine and support mitochondrial integrity in animal offspring, thereby reducing brain injury induced by intrapartum asphyxia.

Creatine supplementation has been shown to act as a possible countermeasure to the menopausal related decrease in muscle, bone, and strength by reducing inflammation, oxidative stress, and serum markers of bone resorption, while also resulting in a concomitant increase in osteoblast cell activity (i.e., bone formation).

Post-menopausal females may experience increases in muscle mass and function when consuming high-dosage creatine (0.3gm/kg/d) for at least 7 consecutive days. When combined with resistance training, the vast majority of research supports the efficacy of Creatine supplementation (≥5gm/d) for improving measures of muscle accretion, strength and tasks of physical performance in post-menopausal females. From a safety perspective, creatine poses no greater adverse effects compared to placebo (https://bit.ly/3opwaGk).

Depression rates are two times higher among females compared to males. The increased prevalence of depression among females has been directly linked with hormonal milestones; major depression rates increase during puberty, during the luteal (high estrogen) phase, following pregnancy, and during perimenopause. Dietary creatine intake is inversely proportional with depression occurrence. Increasing creatine concentrations in the brain as a result of increased animal protein consumption and, more effectively, through Creatine supplementation, has strong evidence to support mood and depression, particularly in females. This has important relevance through various stages across the lifespan that demonstrate increased

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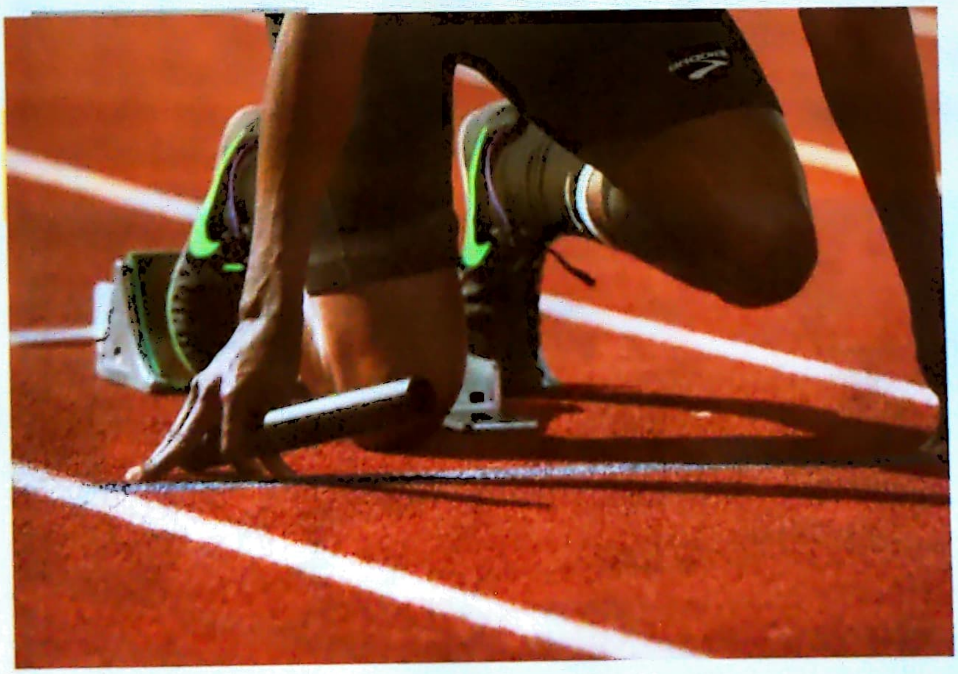
IS CREATINE USEFUL FOR ENDURANCE SPORTS ?

Although creatine supplementation has been theorized to primarily benefit athletes involved in high-intensity intermittent resistance/power type activities, there is a growing body of evidence suggesting that creatine supplementation may also provide beneficial effects for other activities.

Creatine supplementation with carbohydrate or carbohydrate and protein has been reported to promote greater muscle glycogen storage than carbohydrate supplementation alone. Since glycogen replenishment is important for promoting recovery and preventing overtraining during intensified training periods, creatine supplementation may help athletes who deplete large amounts of glycogen during training and/or performance (i.e., sporting events) to maintain optimal glycogen levels.



Creatine is used up as energy during high intensity exercise. Due to this usage, the amount of glucose required from glycogen is decreased a bit.

This both preserves glycogen concentrations in skeletal muscle and reduces lactate production, which is produced when glucose is oxidized for energy.

A study, evaluated the effect of a creatine supplementation protocol upon inflammatory and muscle soreness markers: creatine kinase (CK), lactate dehydrogenase (LDH), prostaglandin E2) (PGE2) and tumour necrosis factor-alpha (TNF-alpha) after running 30km. Runners were supplemented for 5 days prior to the 30km race with 4 doses of 5g of creatine and 15g of maltodextrin per day while the control group received the same amount of maltodextrin.

Creatine supplementation attenuated the changes observed for CK (by 19%), PGE2 and TNF-alpha (by 60.9% and 33.7%, respectively) after running 30km, The athletes did not present any side effects such as cramping, dehydration or diarrhoea, neither during the period of supplementation, nor during the 30km race.

There is also evidence that athletes who supplement with creatine during training experience fewer musculoskeletal injuries, accelerated recovery time from injury and less muscle atrophy after immobilization.

Creatine supplementation (with or without glycerol) has been reported to help athletes hyper-hydrate and thereby enhance tolerance to exercise in the heat. Therefore, creatine supplementation may reduce the risk of heat related-illness when athletes train and/or compete in hot and humid environments.

A study, examined the influence of creatine supplementation on acute cardiovascular, renal, temperature, and fluid-regulatory hormonal responses to exercise for 35 min in the heat. Twenty men were assigned to consume 0.3gm/kg/d Cr monohydrate or placebo, for 7 days. Before and after supplementation, both groups cycled for 30 min at 60-70% VO2(peak)

immediately followed by three 10-s sprints in an environmental chamber at 37deg C and 80% relative humidity.

Body mass was significantly increased (0.75kg) in Cr subjects. Heart rate, blood pressure, and sweat rate responses to exercise were not significantly different between groups. There were no differences in rectal temperature responses in either group. Peak power was greater in the Cr group during all three 10-s sprints after supplementation and unchanged in the placebo group. There were no reports of adverse symptoms, including muscle cramping during supplementation or exercise. Thus, Creatine supplementation augmented repeated sprint cycle performance in the heat without altering thermoregulatory responses.

A study, evaluated the effects of creatine (Cr) supplementation on oxidative stress and inflammation markers after acute repeated-sprint exercise in humans. There were significant increases in tumour necrosis factor alpha (TNF-a) and C-reactive protein (CRP) up to 1 h after acute sprint exercise in the placebo-supplemented group. Creatine supplementation inhibited the

increase of inflammation markers TNF-a and CRP, but not oxidative stress markers, due to acute exercise.

A study, investigated the effects of creatine supplementation on plasma and urinary metabolite changes of athletes after endurance and sprint running. Twelve male athletes performed two 60min running exercises (endurance trial) before and after creatine supplementation (12g creatine monohydrate/day for 15 days). The findings suggested that creatine supplementation tended to decrease muscle glycogen and protein degradation, especially after endurance exercise.

"*If there are any benefits for swimming performance from creatine supplementation, they appear to be limited to a 50 meter sprint or a handful of 50 meter sprints with short intermissions. Excessive sprinting (over six sprints with short breaks) or too long of a break (five minutes rather than two) seem to not be associated with the benefits of creatine supplementation*

Contrary to the popular belief that creatine only enhances short term performance, in swimmers it appears that more prolonged swimming trials see benefit with creatine supplementation by preserving performance in the final stretches

When examining studies with prolonged cardiovascular exercise (i.e. jogs and marathons, but not sprints) creatine supplementation has failed to show significant improvement, although it seems that the potential ergogenic benefits (too small to be statistically significant) may prevent the weight gain from creatine from suppressing performance".

Examples of sport events that may be enhanced by creatine supplementation:

- Track sprints: 60–200m
- Swim sprints: 50m
- Pursuit cycling

- Basketball
- Field hockey
- America Football
- Ice hockey
- Lacrosse
- Volleyball
- Downhill skiing
- Water Sports (e.g., Rowing, Canoe, Kayak, Stand-Up Paddling)
- Swim events: 100, 200m
- Track events: 400, 800m
- Combat Sports (e.g., MMA, Wrestling, Boxing, etc.)
- Soccer
- Team handball
- Tennis
- Interval Training in Endurance Athletes
- Bodybuilding
- Combat Sports (e.g., MMA, Wrestling, Boxing, etc.)
- Powerlifting
- Rugby
- Track/Field events (Shot put; javelin; discus; hammer throw)
- Olympic Weightlifting

INTERNATIONAL SOCIETY OF SPORTS NUTRITION – POSITION STAND - CREATINE

After reviewing the scientific and medical literature in this area, the International Society of Sports Nutrition concludes the following in terms of creatine supplementation as the official Position of the Society:

1. Creatine monohydrate is the most effective ergogenic nutritional supplement currently available to athletes with the intent of increasing high- intensity exercise capacity and lean body mass during training.
2. Creatine monohydrate supplementation is not only safe, but has been reported to have a number of therapeutic benefits in healthy and diseased populations ranging from infants to the elderly. There is no compelling scientific evidence that the short- or long-term use of creatine monohydrate (up to 30g/day for 5 years) has any detrimental effects on otherwise healthy individuals or among clinical populations who may benefit from creatine supplementation.
3. If proper precautions and supervision are provided, creatine monohydrate supplementation in children and adolescent athletes is acceptable and may provide a nutritional alternative with a favourable safety profile to potentially dangerous anabolic androgenic drugs. However, we recommend that creatine supplementation only be considered for use by younger athletes who: a.) are involved in serious/ competitive supervised training; b.) are consuming a well-balanced and performance enhancing diet; c.) are knowledgeable about appropriate use of creatine; and d.) do not exceed recommended dosages.
4. Label advisories on creatine products that caution against usage by those under 18 years old, while perhaps intended to insulate their manufacturers from legal liability, are likely unnecessary given the science supporting creatine's safety, including in children and adolescents.

5. At present, creatine monohydrate is the most extensively studied and clinically effective form of creatine for use in nutritional supplements in terms of muscle uptake and ability to increase high- intensity exercise capacity.
6. The addition of carbohydrate or carbohydrate and protein to a creatine supplement appears to increase muscular uptake of creatine, although the effect on performance measures may not be greater than using creatine monohydrate alone.
7. The quickest method of increasing muscle creatine stores may be to consume app. 0.3g/kg/day of creatine monohydrate for 5–7-days followed by 3–5g/day thereafter to maintain elevated stores. Initially, ingesting smaller amounts of creatine monohydrate (e.g., 3–5g/day) will increase muscle creatine stores over a 3–4 week period, however, the initial performance effects of this method of supplementation are less supported.
8. Clinical populations have been supplemented with high levels of creatine monohydrate (0.3 – 0.8g/kg/ day equivalent to 21–56g/day for a 70 kg individual) for years with no clinically significant or serious adverse events.

ABOUT THE AUTHOR

AKSHAY CHOPRA is the graduate of the prestigious National Defence Academy and the Air Force Academy. He is a former Indian Air Force pilot and has been the captain of the Air Force Bodybuilding team.

He is among the most qualified health, fitness and nutrition consultants, and has one of the richest experiences in the field of sports and fitness in the country and is among the few people to have background of competitive athletics, military training and bodybuilding.

Akshay is a prolific writer & author of multiple books in his field of research, along with hundreds of articles for various magazines and websites.

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A leading fitness entrepreneur, Akshay is the Founder of WE R STUPID, GENESIS, & Co-Founder of MANGOHERBS, and the former co-founder of **Body Mechanics** gyms.